EXHIBIT 47

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

- - - - - - - - - - -

July, 1933

- - - - - - - - - - -

A. D. Butler - City Engineer

Pearse, Greeley & Hansen
Hydraulic and Sanitary Engineers
Chicago, Illinois.

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

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SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

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SUMMARY AND CONCLUSIONS

The sewage disposal problem of Spokane and its solution are difficult to state in specific and simple terms. The river flow is relatively well sustained and in its natural state has had a rapid flow in a rough and rocky channel to the Columbia River some 70 miles below the City. The channel characteristics have been changed by the construction of three relatively large dams below the City and the characteristics of the water have been much changed by the discharge of sewage into the river from the City and its industries. There is no gross pollution of the river comparable to the nuisance conditions in heavily polluted rivers below centers of population throughout the Mississippi Valley, for instance, where very low river flows are often found in dry weather.

However, that the river is polluted by the sewage of Spokane must be obvious. There is visual pollution along the river banks which calls attention to the sewage pollution situation. The bacterial analyses and the probable extent of

bacterial pollution are evidence that the river below Spokane is, at times, polluted so as to make the water hazardous for bathing and recreation. It appears likely that sewage solids accumulate at times along the bottoms of the pools above the Nine Mile and Long Lake Dams forming so-called sludge deposits or sludge banks which tend to concentrate the pollution load as regards depletion of the dissolved oxygen. Analyses of the dissolved oxygen just above these dams show a saturation of 60 percent and at times less, and this is approaching the lower limit of desirable dissolved oxygen concentration. It is my opinion that the dissolved oxygen is likely to be lower along other portions of the river than just above the Nine Mile and Long Lake Dams and that the depletion will increase as the City grows.

These are conditions which the City properly has no right to continue. If the cost were nominal, corrective measures would undoubtedly be taken. The solution of the problem hinges, therefore, on the tolerance of downstream property owners and of the citizens of Spokane who use the river. In my opinion, corrective measures within a reasonable expenditure should be undertaken as soon as they can be financed.

The major elements of the report are briefly stated as follows:

a. The present population of Spokane is 115,514. We estimate 60,000 are connected to the sewers. We have based the capacity of sewage treatment plants on 100,000 connected population and of intercepting sewers on 250,000 population.

b. We estimate that sewage treatment plants should provide capacity for a yearly average flow of 20 M.G.D. and in addition 2.0 M.G.D. of industrial sewage, making a total plant capacity of 22.0 M.G.D. This is a relatively liberal figure and may very likely not increase in direct proportion to the population.

c. The sewage of Spokane and its industries is somewhat stronger than the average. In addition to the human sewage pollution and that of the industries of the City, the pollution load on the river comprises the cleanings of cess pools which are dumped into the river and the up-river pollution from the paper mill and the population in the valley up to Coeur d'Alene. We estimate the population equivalent of this pollution load to be from 172,000 to 287,000, depending in large measure upon the operations of the industries, and have used a population equivalent of 220,000 as typical.

d. The minimum river flow for one day is 1,130 c.f.s. and a flow of 1,700 c.f.s. is not exceeded for 10 percent of the time. The time of flow to the Nine Mile Dam at 1,700 c.f.s. is estimated to be 25 hours and to the Long Lake Dam to be about 36 days, both estimates being based on 50 percent displacement in the pools.

e. A number of river analyses have been made since 1913 by the City Engineer. The minimum dissolved oxygen of record is 5.4 p.p.m. equivalent to 61.5 percent saturation. The number of bacteria counted on agar and the number of B. coli indicated by the analyses are at times higher than what are considered reasonable standards for safe water for bathing.

Several projects for the relief of pollution have been developed in sufficient detail to permit reasonably accurate estimates of cost. The most desirable of these from the viewpoint of cleaning the river comprises a system of

intercepting sewers to deliver the sewage to a single sewage treatment plant located below the built-up portions of Fort Wright. Treatment of the sewage by sedimentation and chlorination is included and this I consider to be sufficient. There is no need at the present time nor for many years to come for a more complete treatment than that provided by sedimentation and disinfection.

Alternate projects of less cost have been considered. The least expensive project comprises three fine screening plants located at intervals along the City, one near Trent Avenue, one opposite Hangman's Creek and one near A Street extended. Fine screens will remove only about 10 percent of the suspended solids as compared to a removal of 50 to 60 percent by sedimentation, and only 5 to 10 percent of the oxygen demand as compared to 30 to 35 percent by sedimentation. Fine screening will not prevent the formation of sludge deposits. Although this is a cheaper project than sedimentation at one site below Fort Wright, it will not sufficiently improve the conditions in the river. The sedimentation project is very much to be preferred.

I have looked into an alternate sedimentation project for the installation of settling tanks with mechanical dewatering of sludge at the Middle Site opposite Hangman's Creek, and also the installation of settling tanks at this site with pumping of the sludge for digestion to the down river site below Fort Wright. On a total annual cost basis the mechanical dewatering of sludge is greater than for

sludge digestion with disposal on open drying beds. The location of the settling tanks at the middle site opposite Hangman's Creek and the pumping of the sludge to digestion tanks at a site below Fort Wright permits of a considerable reduction in the cost of the intercepting sewer system. The total annual cost of this project is $3,000 to $5,000 less than the total annual cost of a single compact sedimentation and digestion plant located at Site A below Fort Wright. As the site opposite Hangman's Creek is limited in area and is relatively close to houses, I do not regard this saving in the annual cost during the life of bonds as sufficient to justify a preference for this project.

The estimated construction and total annual costs of these projects are summarized as follows from Table 9:

Project	Construction Cost	Total Annual Cost
Sedimentation		
Single Plant at Site A	$1,550,000	$ 95,000
Mechanical sludge de-watering at Middle Site		
Open Tanks	1,165,000	99,800
Covered Tanks	1,215,000	113,900
Sludge pumped to downriver site		
Open Tanks	1,315,000	89,700
Covered Tanks	1,365,000	91,800
Fine Screening	750,000	61,200

The total annual costs include operation and a fixed charge at the rate of 6 percent of the estimated

amount required under a Federal Public Works loan now estimated at 75 percent of the total construction cost. Despite the fact that the estimated annual cost of fine screens during the life of bonds is very much less than the estimated total annual cost of sedimentation, I do not believe that the limited improvement of the river by fine screening would justify the saving.

These costs are not unreasonable as compared with costs in other cities. In many places expenditures in excess of $25.00 per capita have been required.

The following summary comments relate to some of the questions which appear to have been up for discussion. In my opinion the sewage of Spokane should be treated by sedimentation and disinfection and that treatment to this extent is sufficient. This treatment will render the water safe for bathing, will remove visual pollution, will prevent the formation of sludge deposits and will reduce the biological oxygen demand so as to remove the threat of lowering the dissolved oxygen in the river below desired limits of saturation particularly as the City grows. I do not believe it practicable or necessary to treat the sewage so as to make the river water suitable for drinking purposes. I do not believe there have been a sufficient number of accurate observations nor a sufficient amount of study to permit complete comment on the effect of the sewage pollution on fish life in the river. I have commented on this in considerable detail in the report and have suggested that a

more comprehensive biological survey of the river would be desirable. It seems likely, however, that game fish have found the stretch of the river from Monroe Street to Nine Mile Dam and perhaps to Long Lake Dam a much less favorable environment since the construction of the dams and that the sewage pollution has been an aggravating factor. I do not regard the pollution of the Columbia River by Spokane sewage, should this water be used for irrigation, as an important factor at the present time, but should irrigation be developed, it would constitute an influence in the direction of the installation of sewage treatment works. The estimated construction costs of the most favorable project for treating the sewage of Spokane is $1,550,000 with an annual cost for maintenance and operation of $25,500.

The foregoing summary and the more detailed statements in the body of the report will, I hope, give you sufficient information upon which to determine a policy as regards sewage disposal. You should weigh the costs in the light of the estimates. If you can arrange to finance the work, the treatment of Spokane sewage by sedimentation and disinfection is desirable.

A - POLLUTION FACTORS

A-1. GENERAL STATEMENT

The pollution load on a waterway is determined to a large extent by the number of people, the kind of sewers and the industries discharging to the stream. These factors are stated in the following paragraphs.

A-2. CITY OF SPOKANE

Spokane had a population in 1930 of 115,514 by the U. S. Census. The increase in 20 years (1910 to 1930) was only 11,000. It is difficult to state what the future population will be, but there are many factors to support a favorable growth. It is important to determine the population for which capacity should be provided so that works to be built will not have to be enlarged too soon after their completion. Practice in this regard in some other cities is given in Tables 1 and 2.

For structures readily added to, such as a sewage treatment plant, an allowance for an increase in the present population of 33 percent is conservative. The basis of design of such structures would be about 155,000 people in the City.

For structures not easily added to, such as intercepting sewers, an allowance for an increase of 120 percent is reasonable. The basis of design of such structures would thus be 250,000.

TABLE 1

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Population Increases for Which Sewage Treatment

Works Have Been Constructed at Various Places

City	Population at Time of Design	Population for which Plant was Designed	Ratio Population for Plant Design to Tributary Pop. at time of Construction
Chicago, Illinois			
North Side Plant	590,000	800,000	1.35
West Side Plant	1,300,000	1,850,000	1.42
Calumet	170,000	225,000	1.32
Milwaukee, Wisconsin	414,000	588,750	1.42
Indianapolis, Indiana	350,000	500,000	1.43
Rochester, New York	250,000	438,000	1.75
Syracuse, New York	150,000	220,000	1.39
Decatur, Illinois	43,818	60,000	1.40
Urbana-Champaign, Illinois	35,000	45,000	1.29
Elgin, Illinois	28,500	37,500	1.32
Oklahoma City, Oklahoma			
North Side	19,600	29,000	1.48
South Side	92,000	136,000	1.48
Springfield, Illinois	58,300	90,000	1.55
Holland, Michigan	15,000	22,500	1.50
Worcester, Mass.	200,000	275,000	1.38
East Orange, New Jersey	86,000	133,000	1.55
Schenectady, New York	94,000	120,000	1.28
Albany, New York	101,000	150,000	1.49
Fitchburg, Mass.	42,000	55,000	1.31
Atlanta, Georgia	60,000	80,000	1.33
Rockford, Illinois	95,000	140,000	1.48
FortWorth, Texas *	165,000	225,000 *	1.36
Muskegon, Michigan *	46,500	78,000 *	1.68
Muncie, Indiana *	35,000	50,000 *	1.43
Peoria, Illinois	73,947	125,000	1.69
St. Joseph, Michigan *	9,210	12,500 *	1.36
Benton Harbor, Michigan *	19,000	23,600 *	1.24
Maximum			1.75
Minimum			1.24
Average			1.43

* Recommended project.

TABLE 2

SPOKANE, WASHINGTON

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REPORT ON SEWAGE DISPOSAL

Population Increases for Which Trunk Line Sewer

Capacity Has Been Provided at Various Places

	Population: Total at Time of Design	Population: Design Basis	Ratio Population Basis of Design to Pop. at time Construction
Chicago Sanitary District *			
(a) North Side Interceptor	590,000	1,450,000	2.46
(b) Calumet Interceptor	110,000	415,000	3.77
(c) West Side	1,200,000	1,700,000	1.42
(d) South West Side	850,000	1,600,000	1.88
Toledo, Ohio - East Side	43,180	164,270	3.80
Toledo, Ohio - West Side	211,520	617,630	2.93
Milwaukee, Wisconsin	414,000	862,000	2.08
Louisville, Kentucky	105,103	274,850	2.62
Philadelphia, Pa.			
Northeastern Division	230,000	740,000	3.22
Southwestern Division	368,000	651,000	1.77
Cincinnati, Ohio - Mill Creek	138,783	308,664	2.22
Cincinnati, Ohio - Ohio River	238,794	303,826	1.27
Cincinnati, Ohio - Duck Creek	31,102	99,320	3.19
Springfield, Illinois	62,000	193,000	3.12
Oklahoma City, Oklahoma	118,000	380,000	3.22
Rockford, Illinois	85,000	210,000	2.47
Benton Harbor-St. Joseph #	25,000	96,000	3.84
Urbana-Champaign, Illinois	35,000	70,000	2.00
Peoria, Illinois	100,000	200,000	2.00
Decatur, Illinois	43,818	120,000	2.74
Bloomington-Normal, Illinois #	33,868	75,000	2.22
Elgin, Illinois	28,260	70,000	2.48
Muncie, Indiana #	35,000	100,000	2.86
Muskegon, Michigan #	46,500	140,000	3.01
Maximum			3.84
Minimum			1.27
Average			2.61

NOTES:

* Interceptors built for treatment projects on combined systems, provided with storm overflows; planned ahead for about 45 years.

\# Recommended Project.

The area within the present city limits is 26,240 acres (41.0 square miles). The area of the City has been extended somewhat during the last few years by the annexation of the Hillyard District and an area near the airport, but has not changed materially for many years. The resulting densities of population are not high, as indicated by the following data:

Total Population	Population per acre of Present City
115,514 - 1930	3.8
155,000	5.9
250,000	9.5

A-3. EXISTING SEWERS

The existing sewers of Spokane are on the combined plan with outlets for the entire capacity of each sewer extending to mid-channel of dry weather stream flow. They are, thus, submerged at all stages. With the river water 10 to 12 feet above the low stage, the discharge of these sewers could not be seen from bridges or shores. The sewer sizes in some cases are too small and the sewers are surcharged. Relief sewers have been planned. Some of the sewers do not have tight joints and their flow is increased by ground water. In general, the existing sewers are well above hihg water in the river and there is, for the most part, ample head for the construction of sewage disposal

works. A brief description of each main sewer district is attached (Appendix 1).

Only about 60,000 people (52 percent of total) are now connected to the sewer system. This is partly due to the large area of the City, and the relatively great distance between a number of the built-up areas. The cost of outlet sewers is relatively high per capita. The people without sewers use cess pools and vaults. Where the subsoil is gravelly, these are said to be satisfactory. It is expected, therefore, that an increase in the percentage of the population connected to the sewers will not be rapid.

A-4. SEWAGE QUANTITIES

An estimate of the quantity of sewage discharged into the river by the existing sewers has been made by the City Engineer on the basis of depth measurements and computations (See Appendix 2). The number of sewer connections in each of the main sewer districts was known from the City permit records and the connected population was computed at the rate of 4.1 people per sewer connection. The data for eight main sewer districts serving 81 percent of the present sewered population is summarized in Table 3. The average rate of flow is 228 gallons per capita per 24 hours. Exclusive of the Trent Avenue District (No. 15), which consists mainly of the packing plants, the average rate of flow is 198 gallons per capita per 24 hours. These are relatively high per capita rates of flow, which are likely to decrease as the density of the population increases. Thus, if a rate

TABLE 3

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Summary of Sewer Gagings and Sewage Analyses

Sewer District No.	Name	1933 Connected Population *	Average Sewage Flow M.G.D.	Gal. per Cap. per 24 hours	Suspended Solids P.P.M.	% Vola-tile	Lbs. per Cap. per 24 hours	5-day B.O.D. P.P.M.	Lbe. per Cap. per 24 hours
1	Nora Street	4,460	0.56	125	155	72	0.16	211	0.22
3	Riverside	5,570	0.44	79	227	74	0.15	284	0.19
6	Cedar Street	4,210	1.10	261	244	82	0.53	304	0.66
12	Division St.	6,810	0.63	92	224	78	0.17	299	0.23
13	Front Street	10,230	2.97	290	90	80	0.22	63	0.15
15	Trent Avenue	240	1.52	6330	501	88	26.40	1079	56.90
19	Lincoln	5,980	3.40	569	137	80	0.65	108	0.51
22	Cochran St.	11,190	0.48	43	351	73	0.13	331	0.12
	TOTALS	48,690	11.10						
	Weighted Averages omitting Dist. 15			198	156	78.5	0.26	154	0.25

NOTE: * Based on 4.1 people per connection.

of 200 gallons per capita per 24 hours be assumed to comprise 100 gallons per capita per 24 hours of ground water, doubling the density of population would result in a per capita flow of 150 gallons per 24 hours.

The average water pumpage for the year 1932 was 28.66 million gallons per day (data from Supt. Alex Lindsay) equivalent to 248 gallons per capita. In 1925, the pumpage per capita is recorded as 292 gallons per 24 hours. These figures tend to support a relatively high per capita sewage flow.

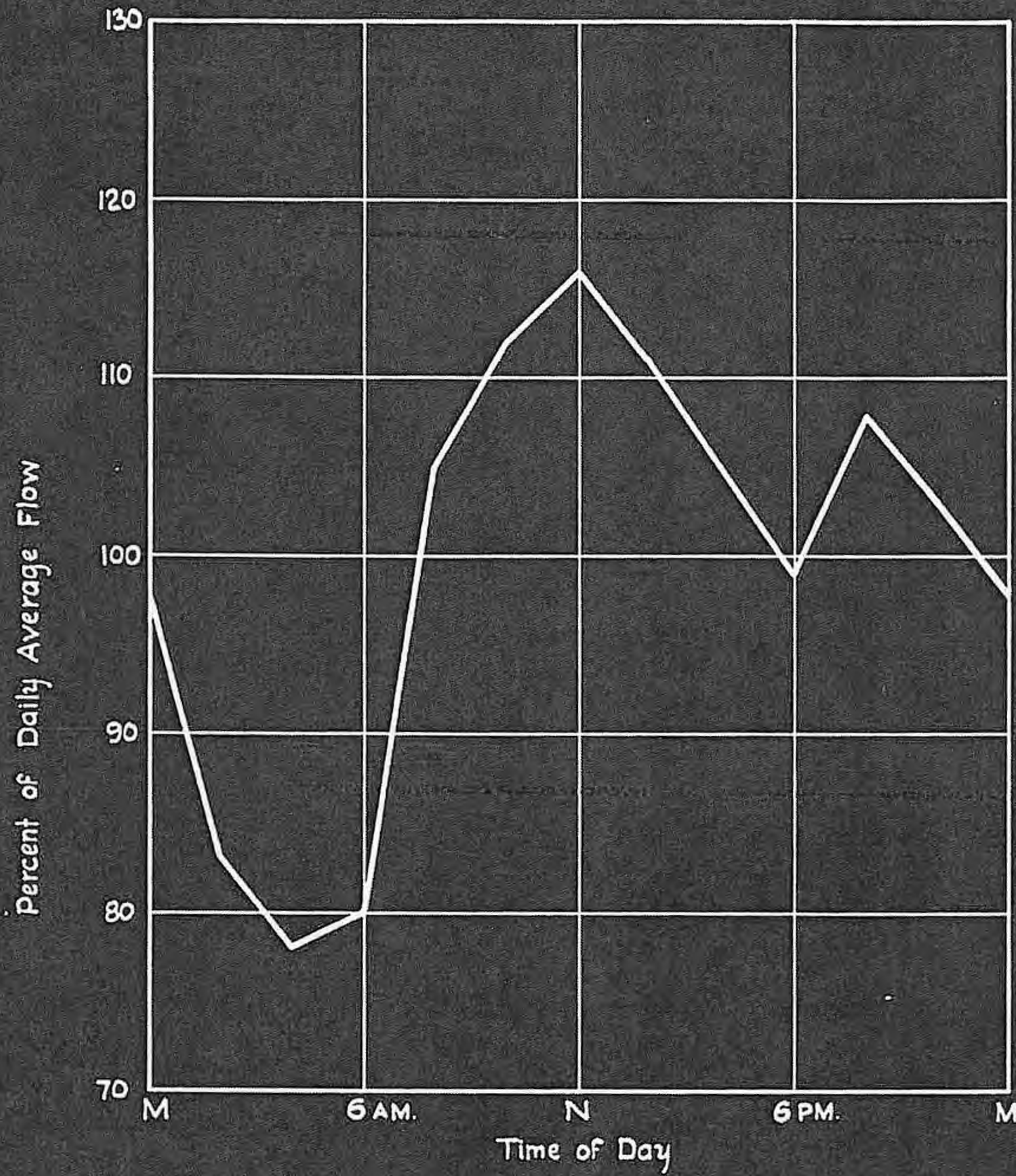
We estimate that sewage treatment plant structures and others readily added to should provide for a yearly average flow of 200 gallons pef capita per 24 hours. In the future as the population density increases, this is likely to be lower, perhaps 150 gallons per capita.

With such relatively high rates of sewage flow, the variations in the flow are not likely to be so pronounced. Figure 1 shows the results of the gaugings by the City Engineer. The maximum flow is 16 percent larger and the minimum flow 22 percent smaller than the average. These are reasonable variations for Spokane.

A-5. SEWAGE CHARACTERISTICS

Samples of sewage from the main sewers have been taken and analyzed (See Appendix 3). The results are summarized in Table 3. Exclusive of the packing houses, it is computed

FIG-1



Note:
Computed from Flow Measurements at 8 sewers May 2-19, 1933.

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SEWAGE FLOW
HOURLY VARIATIONS
JULY 1933

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that 48,450 people produced each day 12,300 pounds of 5-day oxygen demand (B.O.D.) and 12,500 pounds of total suspended solids, equivalent to approximately 0.25 pounds per capita per 24 hours in each case. These are somewhat high per capita contributions, indicating a population equivalent of about 1.5 times the human population.

The future population equivalent of the sewage is difficult to state as the development of even minor industries is uncertain. It is now indicated, however, that in the future the population equivalent of the sewage of the City exclusive of major industries is not likely to be less than 1.5 times the human population.

The analyses indicate an alkaline sewage with a pH well above 7.0 (except the packing house sewage with an average pH of 6.7). The City water is stated to have a hardness of 160 parts per million, practically all of which occurs as calcium carbonate (Table 4). The average percentage of volatile matter in the suspended solids is 78. Thus the sewage should be readily amenable to treatment in biological processes.

A-6. INDUSTRIAL SEWAGES

The major sewage producing industries within the City limits are the following:

Armour and Company
Carsten's Packing Company
United Dressed Meats Company
Trefry Packing Company
Lewis Packing Company

TABLE 4

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Chemical Analysis of City Water

Substance	Parts per Million
Calcium	31.
Magnesium	11.
Silica	13.
Sodium	7.
Iron	Trace
Aluminum	0.9
Sulphate	16.66
Chlorine	2.4
Bicarbonate	174.46
Organic	Trace

The first four are connected to the Trent Avenue sewer. The Lewis Packing Company plant discharges directly into the river about 3,600 feet up-stream from the Greene Street bridge. The kill at all of the packing plants includes hogs, cattle, sheep and calves with hogs predominating, the annual figures for 1932 being given in Table 5. The distribution of the kill over the year is favorable to river conditions in that the months of greatest activity in the packing plants coincide with those of high river flows. The kill during the summer and fall months, when the river flow is low, is slightly more than half of that during the winter and spring months.

The gaugings and analyses of the Trent Avenue (No. 15) sewer made on May 6, 12, 17, 18 and 20, 1933, give the following data:

Item	Amount
Average Sewage Flow	1.525 M.G.D.
Suspended Solids	501 p.p.m.
	6,360 pounds per 24 hours
5-day B.O.D.	1,079 p.p.m.
	13,700 Pounds per 24 hours.

On the basis of the oxygen demand, the population equivalent of the four packing plants is about 80,000; and on the basis of suspended solids, perhaps 45,000. These

TABLE 5

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Summary of Packing Plant Operation - Year 1932

Animal		Total Annual Kill
Hogs		203,400
Sheep		52,000
Cattle		30,500
Calves		3,200
	TOTAL	289,100

Approximate Averages:

Per Working Day (300 per year)

Yearly Average	964	animals	per	day
Winter Average	1350	"	"	"
Summer Average	750	"	"	"

figures appear somewhat high when compared with population equivalents of packing plants elsewhere. The quantity of sewage also seems high. From data obtained at several other cities, the population equivalent to be expected from the indicated kill at Spokane in May, 1933 is 33,000 for all five packing plants.

About seven miles east of the City up-stream along the river at Millwood is the Inland Empire Paper Company's plant with a population equivalent of some 110,000 in the winter and 40,000 in the summer months (See Appendix 4).

There are two saw mills in the City which may put some burden on the oxygen resources of the river; and also two relatively large flour mills. No data is available regarding these industrial wastes. The flour mill waste is probably not large, but saw mill refuse, if allowed to go to the river in quantity, might noticeably affect the formation of sludge banks and the ability of the water to support game fish.

The future pollution load of industrial sewage is difficult to forecast. Based on a study of 19 years of operation of the packing plants at South St. Paul and Newport, the Metropolitan Drainage Commission of St. Paul and Minneapolis estimated a near future increase of 15 to 30 percent and an ultimate increase of 50 percent in the sewage of these plants. For Spokane a near future increase of 20 percent and an ultimate increase of 50 percent are suggested for present consideration.

A-7. UNSEWERED POPULATION

The City Engineer reports 11,872 sewer connections in the eight sewer districts gauged and sampled; and that these represent 81 percent of the total number of sewer connections. The total number is thus about 14,700. Assuming 4.1 persons per sewer connection (based on number of residential water and electric light connections), the present sewered population is about 60,000. Thus only about 52 percent of the present population of the City is sewered. This estimate may be increased at times through the use of the sewers by transients, people in office buildings and apartments, and hotel guests. The remainder are served by cess pools and vaults. The Crematory Division indicates that from about 1300 to 2000 vaults and cesspools are cleaned in a year and their contents dumped into the river. If the contents of each is assumed to be a years' accumulation of polluting matter from one house, and the dumping into the river is assumed to be uniform, the approximate population equivalent of the contents of the cess pools and vaults is 5500 to 8500, or an average of 7000.

A-8. UP-RIVER POPULATION

The City of Coeur d'Alene had a population in 1930 of 8,297 (U. S. Census). Much of this population is sewered to the Spokane River. There is a considerable agricultural population along the river between Coeur d'Alene and Spokane, and the paper mill at Millwood.

The analyses of the City Engineer give some evidence of a depletion of dissolved oxygen at the water works pumping station during periods of low flow. An estimate based on a depletion of 1.0 p.p.m. with a river flow of 1100 M.G.D. (1700 c.f.s.) indicates a loss of 9,150 pounds of oxygen per 24 hours. This would supply the 1-day biological oxygen demand of some 220,000 population. Something more should be added for re-aeration although at the relatively high percentages of saturation prevailing, this would not be a large item. No very definite conclusions can be stated. There is, however, at times a substantial up-river pollution.

A-9. SUMMARY OF POLLUTION LOAD

The foregoing comments on the pollution of the Spokane River may be summarized as follows:

Item	Population Equivalent on B. O. D. Basis	
	Upper Estimate	Lower Estimate
1. Human Population connected to sewers	60,000	60,000
2. Population Equivalent of minor industries	30,000	30,000
3. Unsewered Population	7,000	7,000
4. Major industries in city limits	80,000	35,000
5. Up-river (industrial and miscellaneous)	110,000	40,000
	287,000	172,000

The analyses of the City Engineer of samples from eight sewer districts taken together show a total present discharge of 22,100 pounds of suspended solids and 29,600 pounds of 5-day oxygen demand per 24 hours. On the B.O.D. basis, this is equivalent to a population of about 170,000. To this should be added the up-river pollution and the cleanings of cess pools and vaults.

The depletion of dissolved oxygen in passing through the City is indicated by the analyses to be at times about 1.0 part per million between the water works and the 9-mile dam. At a flow of 1700 c.f.s., this would supply the 1-day oxygen demand of 220,000 people, with no allowance for re-aeration. The pollution load on the river is, probably, at times somewhat more than this figure.

It does not appear unreasonable to say, in the absence of a considerably more detailed analytical record, that the population equivalent of the sewage and wastes now entering the river in the vicinity of Spokane is at times considerably over 220,000 and at other times (Sundays and Holidays, for instance) somewhat below this figure. The present pollution load will probably increase in the future unless the industries change, and this increase may very likely be about the same as the population growth of the City.

A-10. LOADS ON A SEWAGE TREATMENT PLANT

Based on the data contained in the foregoing sections and on the estimated probable growth of the City and its industries, we have set up, for the purpose of cost

estimates, the following loads on a sewage treatment plant for Spokane:

Tributary human population	100,000
Annual average domestic sewage flow	20.0 M.G.D.

Suspended solids

100,000 people at 0.25 - 25,000 lbs. per 24 hours	
Packing plants - - - - - 8,000	33,000 lbs. per 24 hours

5-day B.O.D.

100,000 people at 0.25 - 25,000 lbs. per 24 hours	
Packing plants - - - - - 17,000	42,000 lbs. per 24 hours.

These figures are predicated on the analysis of the packing house sewage made by the City, with an allowance for an increase of 20 percent in the total kill.

B - SPOKANE RIVER DATA

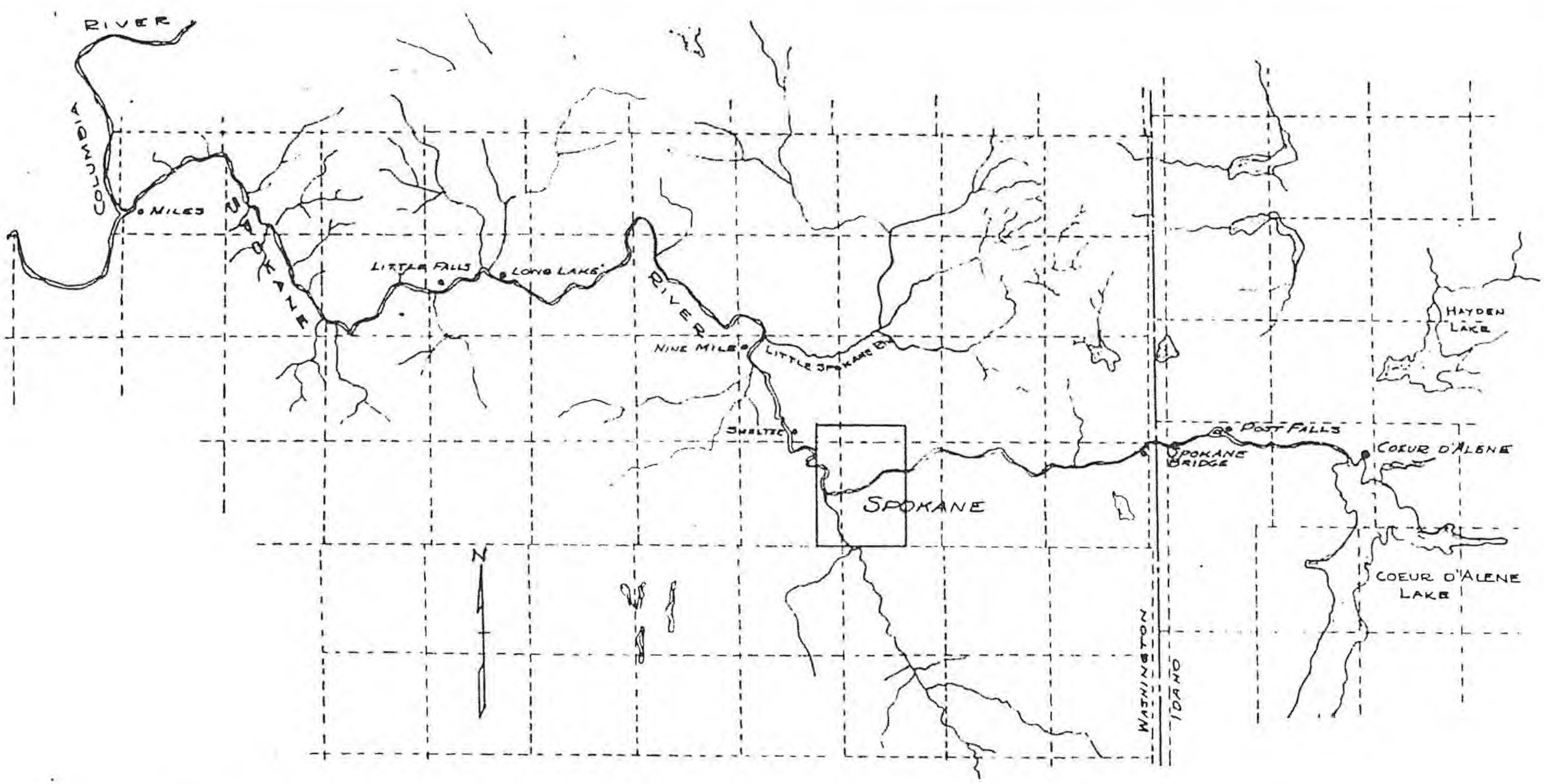
B-1. GENERAL DESCRIPTION

The Spokane River (Figure 2) flows in a westerly direction from Coeur d'Alene Lake to the Columbia River, a distance along the river of about 105 miles. Spokane City is located about 35 miles from the head waters of the river which is the outlet of Coeur d'Alene Lake; and above Spokane the drainage area is 4,350 square miles. The total drainage area above the Columbia River is approximately 6,700 square miles. The steepness of the valley is indicated by the following elevations:

Place	Elevation of Normal Water Surface (U.S. G.S. Datum)	Difference in Elevation
a. Outlet of Coeur d'Alene Lake	2100	
		184
b. City of Spokane		
1. At Waterworks intake dam	1916	
		34
2. At diversion dam above Monroe St.	1882	
		192
3. At Cleveland St. sewer outlet (#22)	1690	
		640
c. Columbia River	1050	

The elevation of the water surface will change many feet between high and low stages and by the operation of the gates at the various dams, but these changes are generally not abrupt.

The channel of the stream is well defined and relatively deep, and in general is gravel and boulders. In its



PEARSE, GREELEY & HANSEN
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6 NORTH MICH. AVE.
CHICAGO, ILL.

SCALE IN MILES
0 2 4 6
1 3 5

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SPOKANE RIVER
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FIG. 2

natural channel, the flow of the water is rapid except at the pools behind the dams.

The valley above Spokane is a relatively wide flat fertile plain between high rugged mountain walls. Much of it is cultivated and under irrigation, there being a great variety of crops including vegetables, grains and fruit. At Millwood is the Inland Empire Paper Company and at Trent is the International Cement Company. This part of the valley is well developed and populated.

The valley below Spokane is rugged with only a few farms. The channel is cut through volcanic outcrops and there are very few flat areas suitable for cultivation. The main occupation is at the three power dams and at occasional resort centers. Great masses of basaltic rock characterize the channel below the City.

B-2. DAMS

Including the controlling works at the outlet of Coeur d'Alene Lake, there are seven dams along the river, as follows:

Designation	Intervening distance along River, in miles
a. Controlling works outlet of Coeur d'Alene Lake	
	8
b. Post Falls	
	22
c. Spokane City: 1. Waterworks	
	5
2. Diversion dam near Monroe Street	
	12
d. Nine Mile	
	27
e. Long Lake	
	3
f. Little Falls	

The dams at Post Falls and at the waterworks are little more than channel dams. Below the City, the dams have the following heights:

Dam	Height in Feet	Length of Back Water in Miles
NineMile	60	5
Long Lake	170	24
Little Falls	70	3

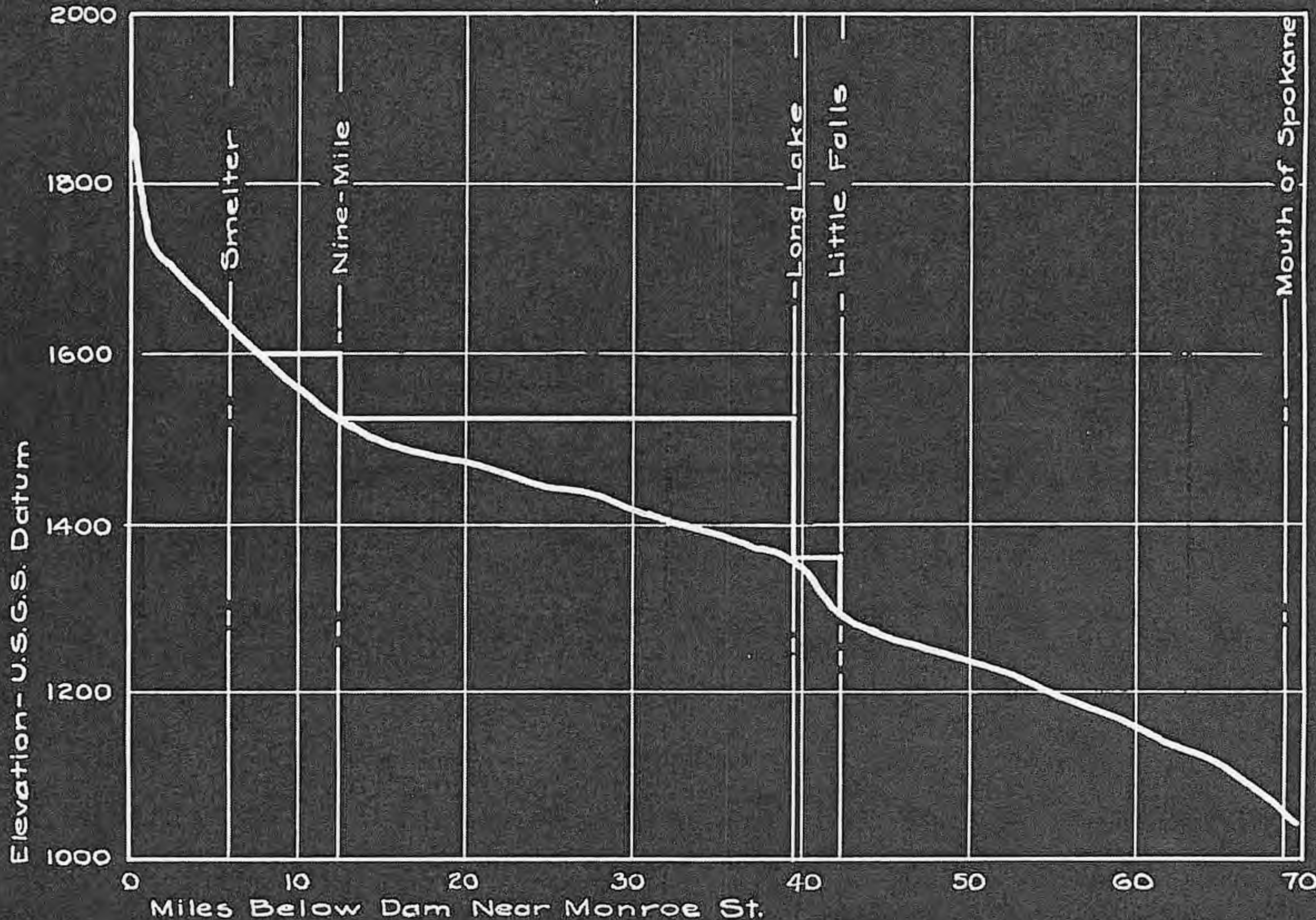
A profile of this section of the river is shown on Figure 3.

B-3. RIVER FLOWS

Although the river flow is partly regulated at low stages, there is always a well sustained flow. The U. S. Geological Survey have published the records of a gauging station at Spokane (now located opposite Cochran Street) since 1892. The frequency of occurrence of various rates of flow is shown on Figure 4, and summarized as follows:

Occurence	Flow in C.F.S.
a. Minimum day of record	1130
b. Not exceeded 10% of the time	1700
c. Maximum day of record	49000

The rainfall at Spokane is moderate, having varied since 1882 from 7.64 to 25.99 inches per year with



SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
PROFILE OF SPOKANE RIVER
JULY 1933

FIG. 3

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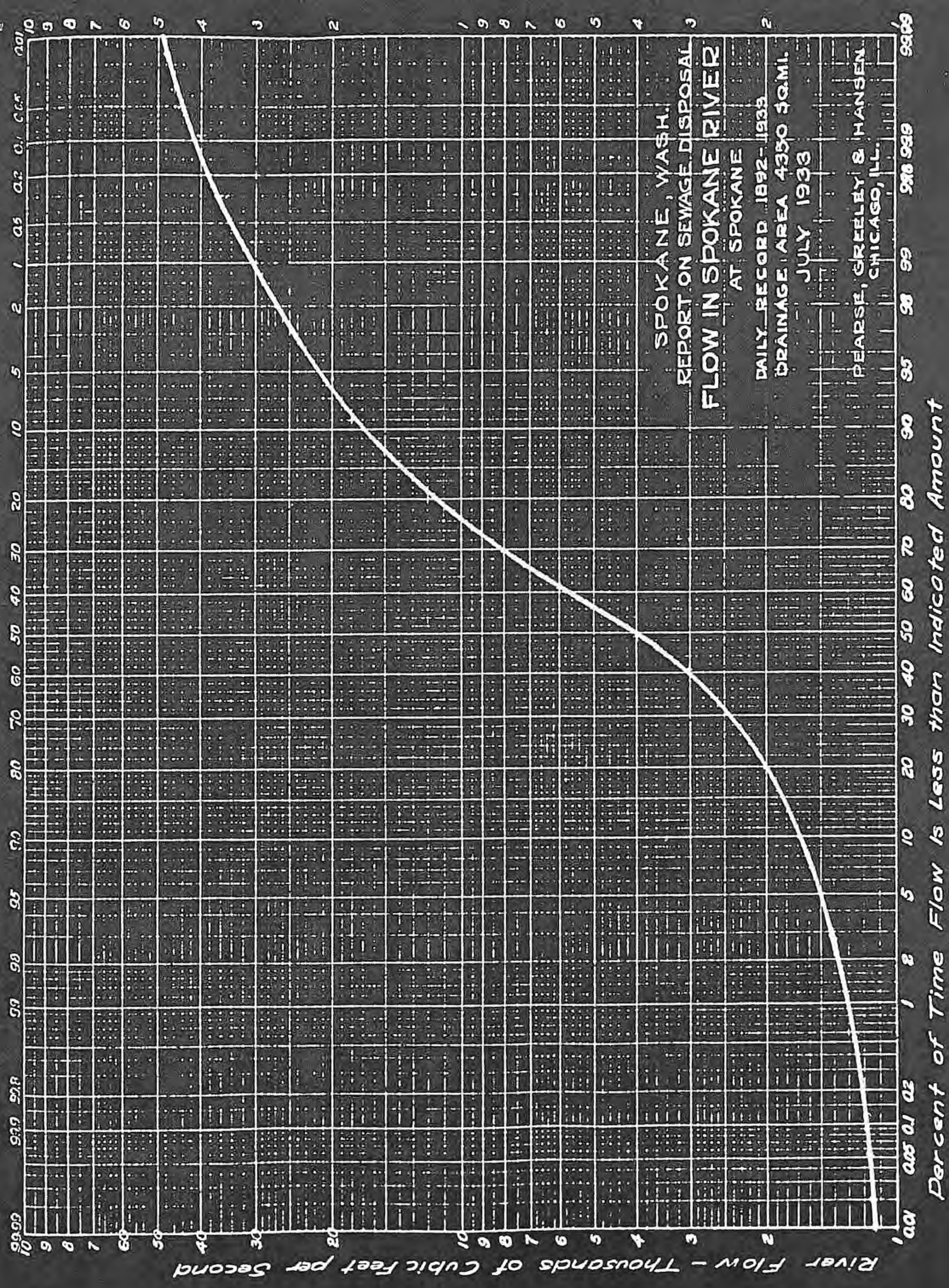
6 NORTH MICHIGAN AVENUE
CHICAGO, ILLINOIS

FIG. 4


SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
FLOW IN SPOKANE RIVER
AT SPOKANE
DAILY RECORD 1892-1933
DRAINAGE AREA 4350 SQ.MI.
JULY 1933
PEARSE, GREELEY & HANSEN
CHICAGO, ILL.
Percent of Time Flow is Less than Indicated Amount
River Flow - Thousands of Cubic Feet per Second

an average annual precipitation of 16.10 inches. The rate of flow in the Spokane River is thus dependent to a considerable extent upon the melting of snow in the mountains and the out-flow of Coeur d'Alene Lake. The result is that the lower rates of flow prevail quite uniformly during the summer and early fall as follows:

Decade Ending with 1930
Rate of Flow in C.F.S.

Month	Monthly			Daily	
	Average	Maximum	Minimum	Maximum	Minimum
Jan.	4,760	9,830	1,560	13,200	1,240
Feb.	6,510	14,800	1,490	22,500	1,340
Mar.	7,270	14,500	2,050	19,300	1,480
Apr.	13,330	23,800	7,160	31,100	2,660
May	17,440	24,700	7,370	28,200	2,340
June	9,190	18,600	3,890	22,000	1,860
July	2,360	3,530	1,520	6,820	1,160
Aug.	1,800	2,410	1,440	2,670	1,160
Sept.	1,760	2,260	1,420	2,760	1,140
Oct.	2,140	5,640	1,390	9,900	1,250
Nov.	3,290	13,100	1,350	23,000	1,240
Dec.	4,980	15,900	1,340	24,500	1,260

B-4. TIMES OF FLOW

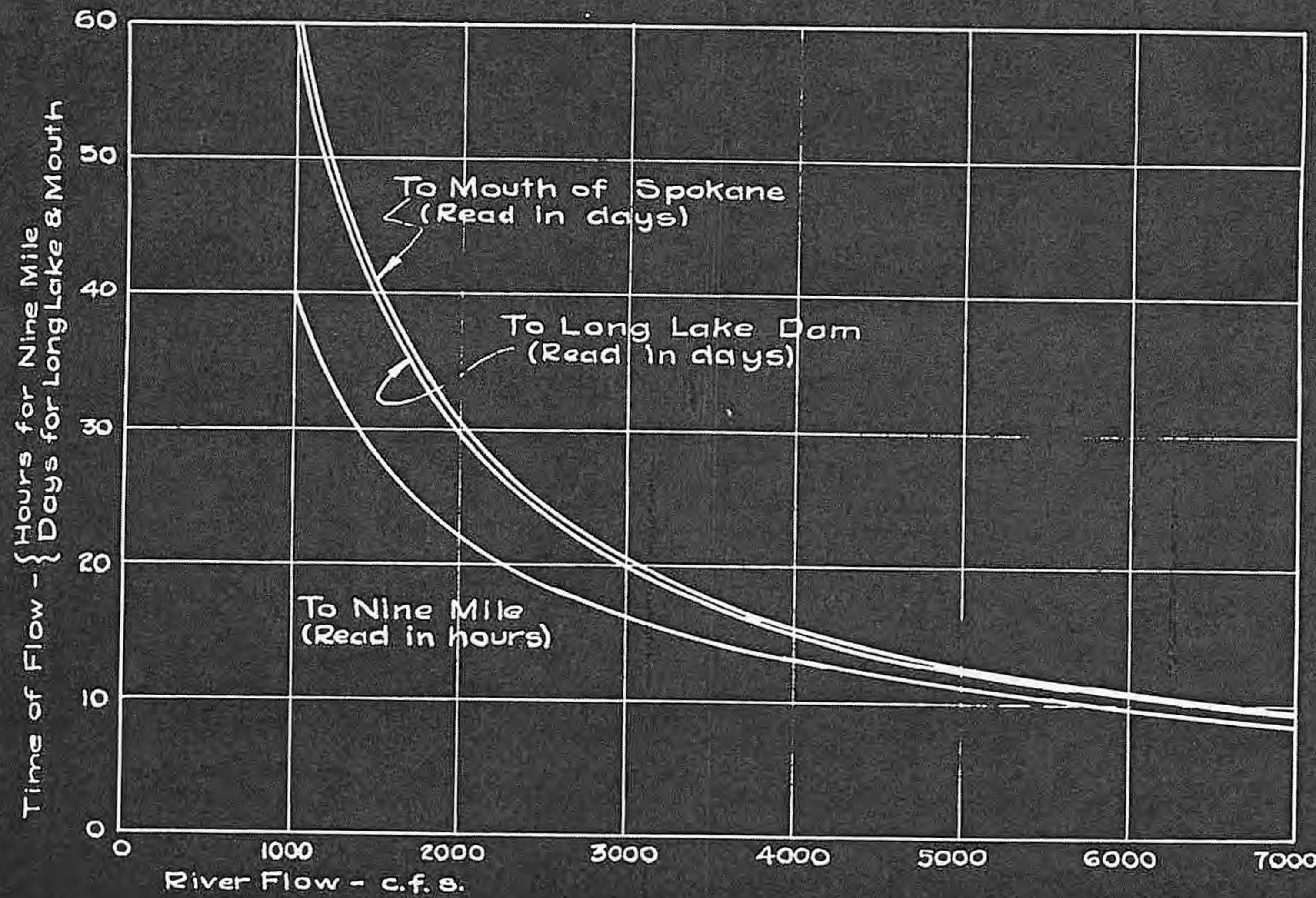
The times of flow in the river from Spokane to various points downstream are quite long, due to the effect of the pools behind the three dams, especially at Long Lake. These pools have the following characteristics:

Pool Back of	Volume at Crest Level Millions of Cubic Feet	Millions of Gallons	Displacement Time in Hours for river Flow of 1700 C.F.S.
Nine Mile	227	1,700	37
Long Lake	10000	75,000	1,630
Little Falls	185	1,400	30

The displacement of the pool water is very probably not complete and there are volumes along the bottom and shores where the displacement is caused by wind-induced currents or by temperature changes rather than by river flow. Thus the time of flow through the pools is probably substantially less than the displacement time indicated above. The times of flow to various points are roughly illustrated by Figure 5, for the purpose of which it was assumed that the actual time of flow through the pools is 50 percent of the total computed displacement time.

B-5. WATER SURFACE

In polluted streams, some of the oxygen demand of the organic pollution is supplied by oxygen absorbed from the air as the river water is exposed in its flow. The rate of oxygen absorption from the air depends a good deal upon the amount of dissolved oxygen in the polluted water. The absorption of atmospheric oxygen is quite rapid when the dissolved oxygen in the water is nearly gone and is very slow when there is but little depletion of this oxygen. The rate



SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
TIMES OF FLOW FROM DAM
NEAR MONROE ST.
JULY 1933

FIG. 5

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CHICAGO, ILLINOIS

of oxygen absorption is more rapid at falls and rapids and where the surface is broken up by winds than in quiet water.

The available analyses of river water below Spokane indicate that the dissolved oxygen is not greatly depleted (Figures 6 and 7). The greatest depletion is just above the dam at Nine Mile, as follows:

Sampling Station	Dissolved Oxygen - 13 Year Record, 1917-1930					
	Parts per Million			% Saturation		
	Aver.	Min. Year	Min. Sample	Aver.	Min. Year	Min. Sample
Pump Station	9.7	8.8	6.2	89	68	62
Smelter	9.6	8.6	7.0	88	73	66
Nine Mile	9.0	7.8	5.3	82	71	61
Mouth Spokane	10.0	8.7	7.4	92	91	78
Lower Columbia	11.0	9.7	8.2	102	91	78
Upper Columbia	11.2	9.9	6.9	102	97	78

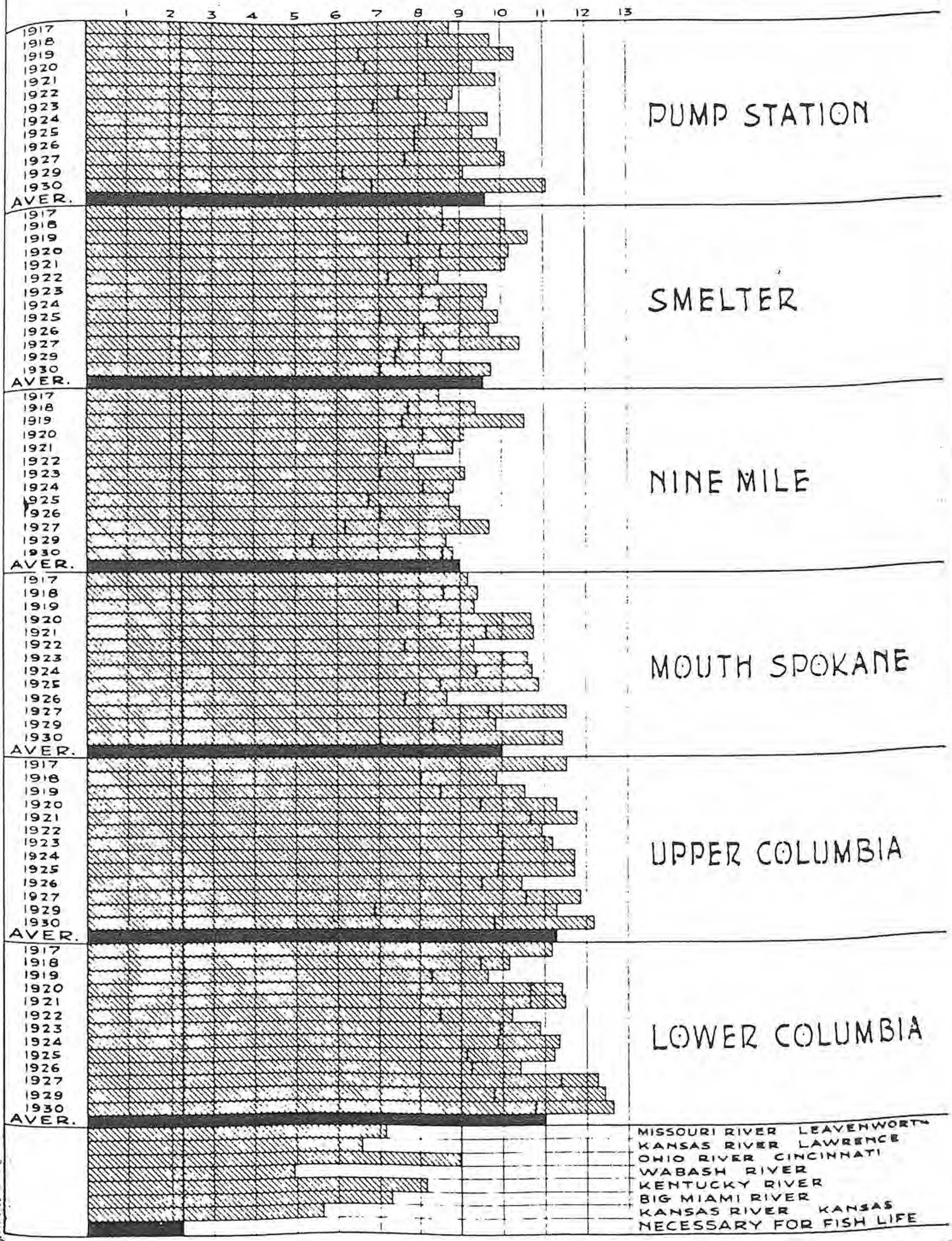
In 1932, the minimum dissolved oxygen at Nine Mile dam was 57 percent saturation.

Under these conditions, we do not consider that re-aeration or absorption of atmospheric oxygen will depend on or vary greatly with changes in the area of the exposed water surface. There is ample opportunity for the river water to recapture such oxygen as it can take up from the air in the flow time available and at the relatively limited depletion in the water itself, without regard to changes in the area of the water surface at different rates of flow. Moreover, in flowing along a rough channel and in rapids, the actual water

FIG. 6

DISSOLVED OXYGEN

PARTS PER MILLION YEARLY AVERAGE



surface exposed to air is greatly increased and computations of the rate of re-aeration would be uncertain. The surface area of the river and pools between the diversion dam and the dam at Nine Mile is about 20,000 thousand square feet. With 70 percent saturation of dissolved oxygen, the absorption from the air might equal 0.50 pounds of oxygen per 1000 square feet of water surface, or about 10,000 pounds per 24 hours. (The 5-day oxygen demand of the Spokane sewage is about 29,500 pounds per 24 hours). The area of the water surface of Long Lake is about 210,000 thousand square feet and offers a good opportunity for re-aeration.

B-6. RIVER ANALYSES

Beginning with the year 1913, the City Engineer has maintained sampling stations along the river starting at the waterworks pumping station just above Spokane and extending to the Columbia River. Samples were analyzed for chemical and bacteriological data. Since 1917 all told about 78 samples have been taken at each sampling station, an average of 4.5 per sampling year. While the number of samples and of sampling points is somewhat limited for an intensive study of the river, especially at possible points of localized pollution, the length of the record is valuable and the amount of information is much more complete than is sometimes available.

B-7. USES OF RIVER WATER AND VALLEY

The problems occasioned by the pollution of a stream are determined in part by the extent to which the pollution disturbs the uses of the river water and the adjacent valley. Among these uses are the following:

a. Water supply (drinking)

b. Recreation (swimming)

c. Irrigation

d. Stock watering

e. Ice (harvested for use)

f. Fishing

g. Industrial use

h. Power

i. Resorts and summer houses (boating, picnics, etc.)

Disturbance is caused (a) by bacterial pollution which tends to spread disease, (b) by the organic matter which, in its natural cycle of change, demands oxygen and tends to cause a nuisance if the dissolved oxygen is too far depleted, and (c) by relatively large floating and suspended particles or slugs of oil and the like, which are unpleasant to the sight, tend to clog the gills of fish, or by concentrating in back water tend to cause unpleasant odors and shore conditions. The bacterial pollution is measured by the number of bacteria found in the water as shown by the agar count and the B. coli determination. The effect of organic matter is measured by the oxygen balance of the stream, and the extent of pollution objectionable to sight and smell is determined by actual ob-

servation . The first five and the last of the foregoing list of uses are disturbed more especially by the bacterial pollution. Most of the uses are affected by the oxygen balance and by obvious pollution of sewage origin.

It is seldom possible to maintain river water in an occupied valley safe for drinking. The criterion as regards water supply is that the pollution should not go beyond a safe load on a water filtration plant. River waters in occupied valleys can, however, be made clean and safe enough for swimming, irrigation, stock watering and the like. The restoration of game fish life by the reduction of pollution is more difficult to state as specific instances are lacking. Sometimes, also, the situation is confused by other factors such as changes in the stream characteristics by the construction of dams and also the actual fishing-out of the stream.

The uses of the Spokane River below the City are limited at present largely to recreation, resorts and power, including fishing and swimming. There are no public water supplies and as yet no irrigation. Stock watering is along the tributary streams. Thus the major factors are the bacterial and the visual pollutions, including some depletion of dissolved oxygen and the accumulation of sludge and scum in back waters. Odors and debris are reported to be objectionable in the power houses during the periodic cleaning of the turbines. The extent of these pollutions is discussed in the following sections.

C - EFFECT OF POLLUTION OF SPOKANE RIVER

C-1. GENERAL

There are few, if any, cities in the United States with river conditions similar to those at Spokane. There are 93 cities in this country with populations of over 100,000. Of these, 30 are on the ocean or on tidal estuaries with discharge into salt water. Of these, Baltimore, with separate sewers, gives complete treatment using trickling filters; New York is building an activated sludge plant for upper Manhattan and portions of the Bronx, has screening plants for many other outlets, and has a comprehensive plan for the disposal of all of its sewage; Los Angeles provides fine screening and Los Angeles County will provide sedimentation; New Haven provides sedimentation and Bridgeport fine screens. The treatment, in general, is moderate.

Another group of the cities of over 100,000 population are on one or another of the large rivers of the country. Of these, there are 16 located on the Mississippi, Missouri, Ohio, Hudson, Tennessee or Connecticut Rivers. Albany has sedimentation and the Twin Cities near the head waters of the Mississippi are planning a progressive installation looking towards complete treatment. None of the others have provided any sewage treatment, although Louisville, Cincinnati and others have plans for intercepting sewers, some of them partly built.

Another group of 10 cities are on the Great Lakes, where the problem of sewage disposal is more acute. Milwaukee has complete treatment by activated sludge while Cleveland and

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Another group of 10 cities are on the Great Lakes, where the problem of sewage disposal is more acute. Milwaukee has complete treatment by activated sludge while Cleveland and

Chicago have large complete treatment plants for part of the sewage. Erie, Toledo and Rochester have sedimentation and Duluth is installing fine screens. Detroit, Buffalo and Gary have no treatment as yet, but general project plans have been prepared.

Still another group comprising 36 cities with populations of over 100,000 are on the smaller rivers of the country. Many of these (58 percent) have provided some form of sewage treatment as follows:

Sewage Treatment in Cities of over 100,000 Population on Smaller Rivers

A Complete	B Partial	C None
Indianapolis	Dallas	Denver (1)
Houston	Syracuse	Portland
Columbus	Dayton	Birmingham (2)
Atlanta	Oklahoma City	Richmond
Akron	Grand Rapids	Youngstown
San Antonio	Tulsa	Nashville
Worcester	Patterson (3)	Scranton
Fort Worth	Trenton	Des Moines (1)
Flint	Wichita	Spokane (1)
Reading		Fort Wayne (1)
Peoria		South Bend
Canton		El Paso
		Evansville
		Utica (1)
		Lowell

NOTES: (1) Problem under consideration
(2) Part of sewage is treated
(3) Passaic Valley Trunk Sewer project

There are, of course, innumerable smaller cities with complete sewage treatment works, as Springfield, Illinois, Flint, Michigan, Marion, Ohio, Fitchburg, Mass., Sacramento, Cal., Madison, Wis., Lexington, Ky., Pasadena, Cal., etc.

These various cities have been prompted to install

sewage treatment works for a variety of reasons. Among them are:

a. Prevention of nuisance

b. Cleansing of waters used for bathing and recreation

c. Maintenance of fish life

d. Protection of water supplies

e. Removal of sludge deposits

f. Cleansing of waters used for stock watering and irrigation.

We consider the prevention of nuisance as the reason which most often occasions the installation of a sewage treatment plant, with the cleansing of water used for bathing and recreation, the removal of sludge deposits and the maintenance of fish life as next in point of numbers. The protection of public water supplies is the most significant reason, but is less frequently a major cause.

Below Spokane, the river is used for recreation, fishing, bathing and power; and may later be used for irrigation if and when the Coulee dam project on the Columbia River is completed. There is no question that the Spokane River is polluted below the City and sometimes objectionably so. The degree of this pollution is discussed in the following sections.

C-2. DILUTION DATA

The quantity of water flowing in rivers available for dilution varies. In some rivers, for instance, minimum flows prevail for longer times than in others. The amount of dilution is often used as an index of the need or extent of

sewage treatment. However, the characteristics of the channel are important, as to whether, for instance, there are pools and backwaters where sludge can be deposited to accumulate in cold weather and become offensive with lower flows and warmer weather. The dilution factor in a number of cities is shown in Table 6. The yard stick is not specific. The Massachusetts yardstick of 6 c.f.s. per 1000 of population has often been quoted, but the application of this to the actual and to the equivalent population is often confused. Below Spokane, based on a population equivalent of 200,000, the river provides a minimum flow of 5.7 c.f.s. and a 10 percent flow of 8.5 c.f.s. both per 1000 of this population; and in the future, if the City and its industries grow, the dilution factor will be less. It is obvious that the river flow at Spokane is better sustained than in many cities where complete treatment of the sewage is clearly needed.

C-3. THE OXYGEN BALANCE

When sewage is discharged into a stream, the organic matter of the sewage takes up the oxygen of the river water. The sewage has an oxygen demand and the river a natural supply. The relation between the two is often termed the oxygen balance. Some of the oxygen supply is in the water and some is absorbed from the air as the normal amount in the water becomes depleted. There is a considerable opportunity for reaeration of the river water below Spokane because of the steepness and roughness of the channel and the fall over the dams. A close oxygen balance is difficult to compute, and the infrequency of river analyses

TABLE 6

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Dilution Factors at Various Places

City		Population, 1930 Actual	Estimated Equivalent	River Flow - C.F.S. 10% of Time	Minimum	C.F.S. per M. of Pop. Equiv. 10% of Time	Mini-mum	C.F.S. per M. Actual Pop. 10% of Time
Dallas	A	260,475	394,000	6	0	0.0	0.0	0.0
Worcester	A	195,311		10	0.5			0.1
Wichita	B	111,110		25	0			0.2
Oklahoma City	AB	185,389		50				0.3
Indianapolis	A	364,161	660,000	200	130	0.3	0.2	0.4
Denver	A	287,861		110	21			0.4
Columbus	A	290,564		Flow very low				
Akron	A	255,040		" " "				
Dayton	B	200,982		400	122			2.0
Twin Cities	B	735,962	1,400,000	2100	1200	1.5	0.9	2.9
Merrimack River Cities	B	334,000		2060				6.2
Grand Rapids	B	168,592	175,000	1200	800	6.9	4.6	7.1
South Bend	B	104,193		1300	400			12.5
Spokane		115,514	220,000	1700	1130	7.7	5.1	15.
Rockford	B	85,864		1400	750			16.
Portland		301,815		(1) 6000	(1) 3500			20.
Cincinnati	B	451,160		13500	5400			30.
Fox River Cities *	B	55,695	800,000	1900	600	2.4	0.8	34.
Hartford	B	164,072		6000	300			36.
Kansas City	C	399,746		18000	5000			45.
Omaha	C	214,006		12000	3300			56.

NOTE: For explanatory notes, see following page.
* Wisconsin.

TABLE 6 (Continued)

Explanatory Notes:

A. Complete treatment installed or badly needed.

B. Partial treatment installed or clearly indicated.

C. No treatment considered necessary at this time.

(1) The river flows for the Willamette River at Portland are estimates arrived at by increasing the flow at Albany, Ore. approximately in proportion to the respective drainage areas.

General Notes:

Dallas has had plans prepared for complete treatment and needs them (works not yet built). Oklahoma City have built partial treatment works and need complete treatment. Indianapolis, Columbus, Worcester and Akron have complete treatment works. Dayton, Trenton, Grand Rapids, Wichita and Rockford have partial treatment works. South Bend, Hartford, Cincinnati and the Twin Cities have preliminary project plans. The Twin Cities are organizing now for construction. Preliminary consideration to sewage treatment is now being given at Denver. Project plans have been prepared for towns along the Fox (Wisconsin) and Merrimack Rivers and some sewage treatment is needed. Omaha and Kansas City have not given much consideration to the problem.

add to the difficulty. The time element is important and the times of flow between Spokane and the Columbia River are increased by the pools back of the dams up to about 50 days at about 1200 c.f.s. (Figure 5). The record of analyses of the City Engineer (Figure 8) shows the dissolved oxygen of the river water just above the Nine Mile dam to be depleted to about 60 percent saturation in the summer time. The minimum is 57 percent.

Based on a recent study of the shore waters of New York, Connecticut and New Jersey in the vicinity of New York City, the legislatures of the three states have passed acts regulating the pollution of these shore waters by sewage which is summarized as regards depletion of dissolved oxygen as follows:

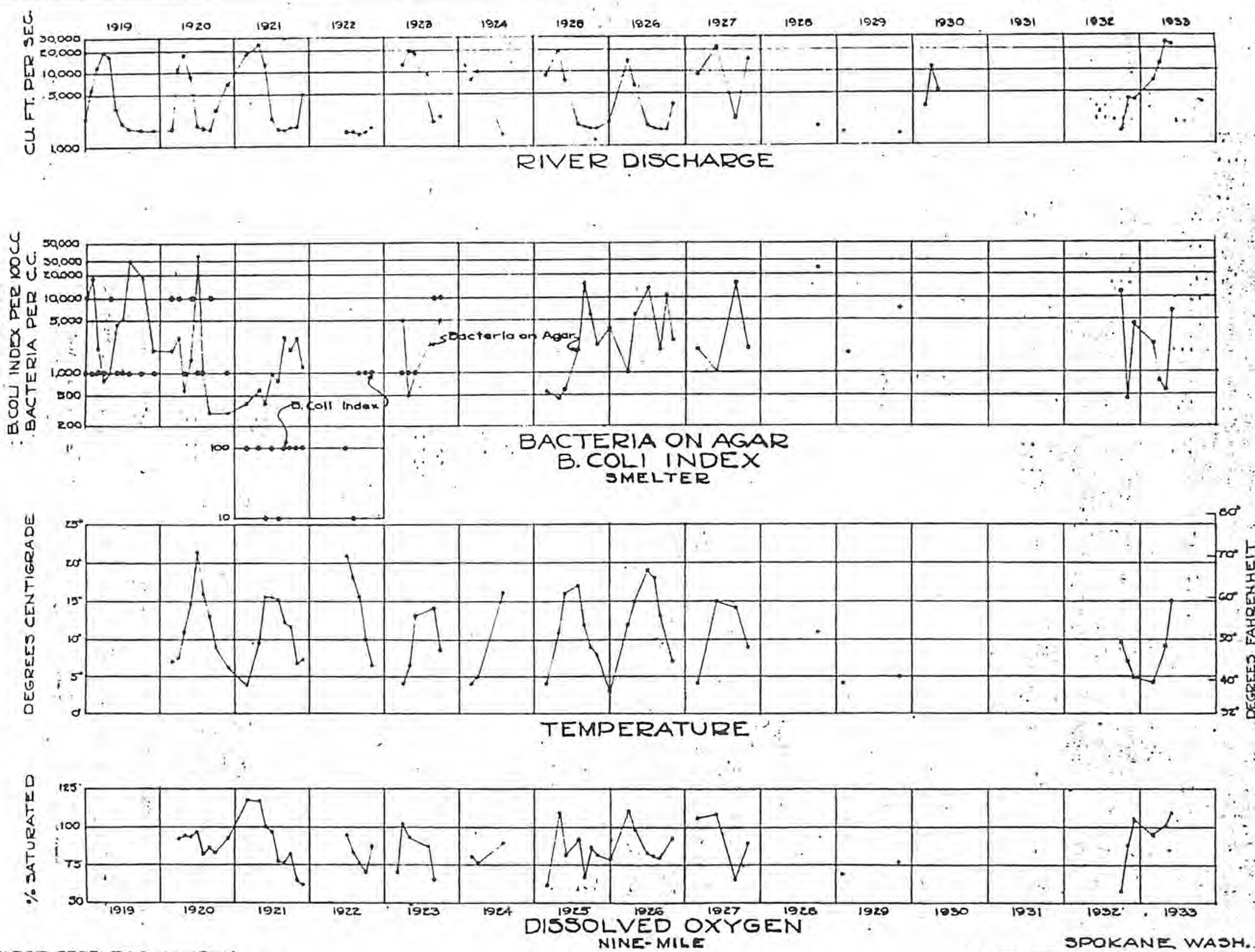
"Two general classifications shall be used:

(1) Class "A", in which the designated water areas are expected to be used primarily for recreational purposes, shell-fish culture or the development of fish life.

(2) Class "B", in which the designated water areas are not expected to be used primarily for recreational purposes, shell-fish culture or the development of fish life."

"(c) to effect a reduction in the oxygen demand of the sewage effluent sufficient to maintain an average dissolved oxygen content in the tidal waters of the Treaty Area and in the general vicinity of the point of discharge of the sewage into those waters, at a depth of about 5 feet below the surface, of not less than 50% saturation during any week of the year."

The Metropolitan Sewerage Commission of New York



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SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
RIVER DATA
JULY 1933

FIG. 8

has given a very large amount of attention to the depletion of dissolved oxygen in the waters adjacent to New York City and have summarized their opinion as follows:

"Except in the immediate vicinity of docks and piers and sewer outfalls, the dissolved oxygen in the water shall not fall below 3.0 cubic centimeters per liter of water. (With 60 percent. of sea water and 40 percent. of land water and at the extreme summer temperature of 80 degrees F., 3.0 cubic centimeters of oxygen per liter corresponds to 58 percent. of saturation.) Near docks and piers there should always be sufficient oxygen in the water to prevent nuisance from odors."

This conclusion was submitted to a number of men experienced in sewage disposal problems and their opinions were summarized by John D. Watson of Birmingham, England, as follows:

"What the standard should be is a question which you have already submitted to a number of well-known experts, and they have all united in saying that the dissolved oxygen in the harbor water should not be allowed to fall below 50 per cent. or 60 per cent. of the saturation limit. Colonel Black and Professor Phelps suggested that it should not be allowed to fall below 70 per cent. saturation, and this figure is more in accordance with my own view; indeed, I go further and say that an even higher standard is feasible if the project recommended later in this report is approved and given effect to."

The Metropolitan Commission of Minneapolis and St. Paul, after conference with the Minnesota State Board of Health, indicated a dissolved oxygen content of 4.0 p.p.m. as necessary if fish life were not to be seriously disturbed; with 2.0 p.p.m. as the minimum for the prevention of nuisance. At temperatures prevailing in the Spokane River during the summer months, these are equivalent to about 42 and 21 percent of saturation respectively. All standards stated in terms of dissolved oxygen saturation must, of course, be considered with reference to the amount of suspended matter discharged into the waterways, to the absence or presence of sludge deposits, and to the development of localized nuisances.

I do not consider that a close computation can be made for the Spokane River without many analyses because of the difficulty of computing the re-aeration.

It appears that the dissolved oxygen in the Spokane River in the pool above Nine Mile dam is depleted to about the point indicated as a limit by the Tri-State Agreement of New York, New Jersey and Connecticut, and by the Metropolitan Sewerage Commission for New York Harbor, and may be occasionally below this figure.

C-4. BACTERIAL POLLUTION

In some cases of waterway pollution, the bacterial pollution is important even when there is little or no depletion of the dissolved oxygen. This is the case when sewage is discharged into the ocean or large lakes near centers of population. The sewage of Los Angeles City and County does

not/ appreciably deplete the oxygen of the ocean waters, but the bacterial pollution of the bathing beaches and harbor waters is jealously guarded.

The bacterial pollution is often measured by the number of bacteria which will develop on agar plates in 48 hours at 37 degrees C. per cubic centimeter of river water, and by the indicated number of B. coli (generally per 100 c.c.) present. The B. coli index is the more frequently used. Bacterial analyses of the Spokane River have been made for a number of years by the City Engineer (Figure 8).

A number of investigators have studied the question of the allowable B. coli index for waters used for bathing. The results may be summarized as follows:

Authority	Limiting Number of B. coli per 100 c.c.
a. Connecticut Dept. of Health	
Class A	50
Class B	500
Class C	1000
b. New Jersey Beaches - 1932	84
c. C. E. A. Winslow for New Haven Harbor	
Average	100
Maximum	1000
d. California State Board of Health	1000
e. Chicago Bathing Beaches - Average	850
f. North Shore Sanitary District - Average at Bathing Beaches	3887
g. Charles River, Mass. - Average	3940

As a result of analyses of the Charles River basin just below Watertown and down as far as Cambridge, the Massachusetts Department of Public Health advised that bathing in this stretch of the Charles River be discontinued.

The record of analyses of B. coli in the Spokane River are not as complete as the record of the agar count. This is partly because after 1924 analyses were made of 10 c.c., 1.0 c.c. and 0.1 c.c. samples, whereas prior to that time analyses were also made of 0.01 c.c. samples. The presence of B. coli in a 0.01 c.c. sample indicates 10,000 B. coli per 100 c.c. In the absence of a negative test in 0.1 c.c. samples, it cannot be assumed that B. coli will not be confirmed in a 0.01 c.c. sample. Thus if the analyses since 1924 at times showed 1,000 B. coli per 100 c.c. (by a confirmed test on a 0.1 c.c. sample); the number of B. coli in the river water might have been higher, just as it was found to be prior to 1924.

From long and exhaustive studies of the bacterial pollution of the Ohio and Illinois Rivers, the U. S. Public Health Service have stated that the summer counts on agar are about 157 times the B. coli counts. The maximum number of bacteria (agar count) in the Spokane River at the Smelter sampling station during the summer is reported by the City Engineer as about 30,000 per c.c. This would indicate some 19,000 B. coli per 100 c.c. Quite a number of the agar counts were in excess of 10,000 bacteria per c.c., indicating a B. coli count in excess of 6,000 per 100 c.c.

While this bacterial pollution is not as marked as in the Mississippi River below the Twin Cities, the number of B. coli, at times, is in excess of a desirable limit for water used for bathing and recreation. The average number of B. coli in the Spokane River at the Smelter prior to 1924 was found to be 2300 per 100 c.c. for the summer months and 2600 per 100 c.c. for all of the samples. Four out of 22 samples analyzed showed 10,000 B. coli per 100 c.c. Bathing beaches have been closed in Massachusetts with B. coli counts of between 3000 and 4000 per 100 c.c.

The bacterial pollution of the river below Spokane is, in my judgment, at times (chiefly in the summer months) beyond the safe limit for water to be used for bathing and recreation.

C-5. VISUAL POLLUTION

Sewage caries a considerable amount of floating material such as garbage, feces, toilet paper, soap and oil. Such substances tend to strand along the shore, in back waters, behind logs and debris and in the quiet waters of pools. These strandings are unpleasant to see and mar the use of the water for recreation. They are also objectionable when they occur in the built-up parts of the City. Whatever objectionable there may be in visual sewage pollution is reduced in its effect in the river through Spokane by the submerged sewer outlets and by the fact that most of the river shores are relatively inaccessible. Such strandings occur along the shores below the City.

C-6. SLUDGE DEPOSITS

The deposition of sewage solids and so-called sludge deposits or sludge banks is an important item in a stream cleaning problem. In commenting on the effect of sewage pollution of the waters in the vicinity of New York City, the Tri-State Treaty Commission stated " of equal importance is the existence of sludge deposits on the bottom which have a serious effect on the growth or survival of fish eggs deposited thereon." The Wisconsin State Board of Health, in a report in January, 1927, on stream pollution in Wisconsin, makes a similar statement to the effect that "sludge settling over the spawning beds of fish cause them to seek other spawning grounds or prevent natural development of the spawn." Sludge deposits also tend to disturb the oxygen balance by concentrating the oxygen demand in certain portions of the stream with a tendency to, or possibility of local nuisance or of the accentuation of visual pollution. Sometimes floating scum and sludge originate by the gas lifting of sludge deposits.

There is a considerable opportunity for the formation of sludge deposits in portions of the pools back of the dams at Nine Mile and Long Lake. The velocities at various river flows in three of the cross sections of the Long Lake pool on the basis of complete displacement through these three sections are as follows:

Month	River Flow C.F.S.	Velocity - Feet per Minute At D-D	At C-C	At B-B
1932				
January	2,660	6.9	4.0	2.1
February	2,500	6.5	3.8	2.0
March	11,600	30.2	17.6	9.2
April	23,800	62.1	36.0	18.8
May	29,800	77.7	45.1	23.6
June	14,100	36.8	21.4	11.1
July	2,600	6.8	3.9	2.1
August	1,510	3.9	2.3	1.2
September	1,440	3.8	2.2	1.1
October	1,540	4.0	2.3	1.2
November	5,400	14.1	8.2	4.3
December	5,230	13.6	7.9	4.1
Average	8,500	22.2	12.9	6.7

Section	Miles above Dam
B-B	11.1
C-C	15.7
D-D	19.8

The velocity of flow in a sewage settling tank is not ordinarily over 2.0 feet per minute or thereabouts. Thus, there would be opportunity for sedimentation in portions of the Long Lake pool and it is probable that much of the suspended matter of the sewage during periods of low flow in the River will settle out in this and in the Nine Mile pool. No cross sections are available in the Nine Mill pool, but it is very likely that sludge deposits will form in some of the back waters above this dam. It has been reported that when

the Long Lake pool was drained a few years ago the bottom deposits in the upper half of the lake showed evidence of sewage origin.

The removal of suspended solids, except in complete treatment works, is best accomplished by sedimentation. Fine screens remove the coarser suspended solids and in general not over about 10 percent of the total suspended matter. A much better cleaning of the river results from sedimentation, which removes practically all of the settling and up to 60 percent of the total suspended solids, and this is generally included as a very desirable step in the removal of pollution from a river even where there are substantial quantities of river water.

C-7. EFFECT OF POLLUTION ON FISH

Sewage discharged into a natural body of water generally has some effect upon the fish life. Sometimes, because it increases the growth of fish food in the river, the sewage increases the number of fish. Some kinds of fish are more sensitive than others to changes in their environment, and young fish are more sensitive than adults. Trout, white fish and bass are among the sensitive varieties, and carp, suckers, buffalo and minnows are less disturbed by adverse conditions.

The effect of sewage pollution on fish is generally along the following lines:

a. Suffocation by depletion of the dissolved oxygen

b. Interrupted breathing by clogging of the gills with fibrous and coarse suspended matter

c. Poisoning by special kinds of pollution as, for instance, hydrocyanic acid from plating works.

d. Disturbance of propagation by sludge deposits on the bottom in quiet water where spawning is more likely to be attempted.

e. Breathing made difficult by the adherence of oily wastes to the gills of the fish

f. Greater liklihood of disease through stimulation of fungus growths in the water.

The extent as well as the intensity of the pollution is important and the opportunity of swimming away from areas of intense pollution or pollution effect. The dams across the Spokane River may be a factor in this way. Thus, fish are more or less confined within the stretch of river between the diversion dam off Monroe Street and the dams at Nine Mile and Long Lake; at least, travel of fish up and down stream from this stretch is more difficult than in the natural channel.

The Metropolitan Drainage Commission of Minneapolis and St. Paul have suggested a minimum quantity of dissolved oxygen of 4.0 parts per million for the reasonable support of fish life in the Mississippi River below these two cities.

From experiments conducted for the Sanitary District of Chicago, Dr. Lederer reached the following conclusions:

"Fish life is affected by material in suspension and solution. Material in suspension may cause disease by fungus growths or death by mechanical stoppage of the gills or suffocation. For continuous fish life a content of dissolved oxygen of at least 2 to 3 parts per million is required by practically all the fish used by us. For very short periods fish may live in a content of dissolved oxygen between 1 and 2 p.p.m."

Extensive studies have been made on fish life in the Illinois River by the Division of Natural History Survey of the State of Illinois. The following quotation is from Bulletin Vol. XV, Article VII (1925) by David H. Thompson:

"It seems quite certain that dissolved oxygen concentrations between zero and two parts per million will kill all kinds of fishes. Carp and buffalo have been found living in water showing as low as 2.5 parts per million. As a rule, a variety of fishes were found only when there were four or more p.p.m. and the greatest variety of fishes were taken when there were nine p.p.m.

"It was noticed a number of times that carp and buffalo taken from oxygen-deficient water were very light in color and sluggish in their movements, while the same kinds of fishes taken from well aerated water were quite darkly pigmented and very active when disturbed."

The following notes are taken from the Annual Report of 1921 of the Conservation Commission of the State of New York. With reference to dissolved oxygen in the

water, it is stated: "Fish requirements vary with the species and age of the individual. It has been said by one authority that few fish are found when the oxygen saturation is below 40% (about 4.5 p.p.m.) and none where it is below 30% (about 3.7 p.p.m.). These figures are perhaps high, for fish have been known to live where the dissolved oxygen was 1.5 p.p.m., probably less than 20% saturation. Conditions favorable for growths of fungi would tend also to favor the various fungus diseases to which fish are subject. Fish eggs deposited in organic sludge or in the zone of fungus growth would be destroyed in a short time." The following tabulation is included:

" Essential Requirements of Fish

Name	Oxygen	Spawning
Brook trout	Hihg	Oct. to Jan. in clean gravel shallows
Landlocked salmon	High	" " " " " " "
Small mouth bass	High	May to July on clean gravel
Yellow perch	High	March and April on water plants
Large mouth bass	Medium	May to July - clean places
Sunfish	Medium	Summer in hollows along shore
Bullheads	Medium	May to July on clean mud and stones
Minnows:		
Stoneroller	Low	Spring and summer clean sand
Shiner	Low	" " " " "
Creekchub	Low	" " " " "
Sucker	Low	April and May eggs scattered.

In the State of Wisconsin the effect of stream pollution on fish life has received considerable study. The following extracts are taken from a joint report of the Conservation Commission and the State Board of Health entitled "Stream Pollution in Wisconsin", January, 1927:

"Pollution may affect fish life in any or all three ways: (1) direct killing of fish; (2) changes of tural conditions so that the fish seek other habitat her because of the condition of the water or the effect the wastes upon plant or lower animal life constituting ish food; (3) influence on fish larvae and young fish.

"Investigations in the Illinois River and data esented by the Bureau of Fisheries, U. S. Department of merce indicates that if the dissolved oxygen content of e water drops below two parts per million, fish will pro- bly suffocate or migrate. The discussion above in regard dissolved oxygen refers specifically to the effect upon ult fish. The indirect effect due to changes of natural nditions appears to be somewhat indeterminate but is pro- bly a material factor. Fibre and other sludge settling er the spawning beds of fish cause them to seek other wning grounds or prevent natural development of the spawn. . . . Eggs taken from pike in the polluted waters of the River could not be successfully hatched in this same water had to be transferred into more pure water. It is thus dent that pollution has a much more deleterious effect on the eggs and young fish than upon the adult fish."

Certain industrial wastes are of particular concern se they attract fish and at the same time are toxic. Wastes m gas works are in this class. M. C. Marsh in U. S. G. S. er Supply Paper No. 192, 1907, reports that tar from the of wells killed perch in dilution 1 : 100,000. Prof. Knight in contributions to Canadian Biology, 1901

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Certain industrial wastes are of particular concern since they attract fish and at the same time are toxic. Wastes from gas works are in this class. M. C. Marsh in U. S. G. S. Water Supply Paper No. 192, 1907, reports that tar from the gas wells killed perch in dilution 1 : 100,000. Prof. A. Knight in contributions to Canadian Biology, 1901

reports that waste water from gas works in 0.5% dilution killed trout in 10 to 15 minutes and smelt in 15 minutes but did not kill sunfish and salt water chub exposed for several days.

Some instances have been reported where large numbers of fish have been killed by the clogging of their gills by coarse industrial waste.

There is not enough river data to permit a complete or conclusive statement as to the effect of the sewage pollution upon the fish in the Spokane River. A number of observers stated that fishing below the City had been "ruined". The change by some was related to the construction of the Nine Mile and Long Lake Dams. The characteristics of the river have, of course, been changed by the construction of dams and the pollution of the sewage. The natural plant and animal life in the waters has very likely been greatly changed. A biological survey of the river water below Spokane over two or three years would, in my opinion, be highly desirable. It might embrace the following topics:

a. Present fish life in this stretch of the river.
b. Departure of present fish life from the natural one as evidenced by early records, observations in Spokane River above Millwood, and fish life in other similar streams.
c. Character of bottom deposits.
d. Character of shore growthds and growths on rocks.
e. Plankton and fish food in the water.
f. Distribution of dissolved oxygen.
g. Spawning places
h. Facility of fish travel up and down the river.
i. Effect of dams, pools and changed channel

Such a survey might be undertaken by the natural history department of the State or the State University.

As a preliminary statement, it appears to me that game fish (trout, bass, etc.) have found the stretch of river from Monroe Street to Nine Mile dam and perhaps to Long Lake Dam a much less favorable environment since the construction of the dams and that the sewage pollution has been an aggravating factor. The game fish have apparently been reduced and the more adaptable varieties (carp, suckers, etc.) appear to have increased. Just how far a reduction of the sewage pollution load will increase the number of game fish, I am unable to say. A biological survey, as suggested above, will help in determining this question and in planning for restoring the game fish life.

C-8. OXYGEN DEMAND OF THE RIVER WATER

A few analyses are available of the 5-day biological oxygen demand of the Spokane River water. Of three samples each at the Smelter and Nine Mill stations, the maximum 5-day B.O.D. was 2.80 and 2.71, respectively and averages 1.32 and 2.0, all in parts per million. The river flow was high in all cases.

There is generally some organic pollution of natural river waters by surface run-off from fields and forests. The amount varies in different streams. The data for Spokane are too meager and at too high river flows to justify any computations.

C-9. SUMMARY STATEMENT

While the sewage pollution of the Spokane River below the City is not marked by gross nuisance, there is, nevertheless, objectionable pollution. The bacterial pollution is, in my opinion, sufficient to make the water hazardous for bathing and recreation, especially during periods of lower river flows which generally occur in the summer and fall months. The visual pollution further mars the stream and its shores for recreation. The dissolved oxygen is, at times, depleted to about the safe limit set by several commissions and occasionally is depleted below this limit. The number of game fish in the river below the City appear to have decreased in the last 20 years, although the extent to which sewage pollution contributes cannot as yet be stated. The construction of the dams has tended to accentuate these undesirable effects, in part by sedimentation in pools back of the dams and in part by retarding the flow during the first few miles below the City. Such pollution conditions will increase as the City grows. This pollution should not continue longer than necessary. Remedial measures should proceed along the following lines:

a. Reduction of the bacterial pollution by clarification and disinfection of the sewage.

b. Removal of visual pollution.

c. Reduction of the organic matter of the sewage so as to prevent any further depletion of the dissolved oxygen.

d. Removal of settling suspended solids so as to maintain clearer river bottoms and shores and to decrease the odor hazard

That the river is polluted by the sewage of Spokane must be abvious. There is visual pollution which calls attention to the sewage pollution situation in the river and is objectionable from the recreational viewpoint. The bacterial analyses and the probable extent of bacterial pollution based on experience elsewhere are evidence that the river below Spokane is, at times, polluted so as to make the water hazardous for bathing and recreation. The effect of sludge deposits on concentrating the pollution load in some stretches of the river, probably in the pool above the Nine Mile Dam and the headwaters of Long Lake, is not reflected in the available analyses, as the samples were taken just above the dams and 12 to 18 inches below the surface. In commenting on the effect of sludge deposits, the Engineering Board of Review of the Sanitary District of Chicago states that "the total oxygen demand exerted by the sludge deposits - - - - is more than the oxygen demand of the sewage. This is possible because of accumulations during cold weather of inactive sludge which exert a large oxygen demand in summer".

These are conditions which the City has properly no right to continue. If the cost were nominal, corrective measures would undoubtedly be taken. The solution of the problem hinges, therefore, on the tolerance of downstream property owners and of the citizens of Spokane who use the river. In my opinion corrective measures within a reasonable expenditure should be undertaken as soon as they can be financed.

I have made no specific comments on the effect of the pollution on the use of the river water for irrigation, because at the present time there is no such use below the City. The construction of a dam across the Columbia River is anticipated and when this is completed it is understood that river water from the Columbia a short distance below the entrance of the Spokane will be used for irrigation. The effect of Spokane sewage upon the bacterial content of the Columbia River water at this point cannot be stated at the present time. Bacterial analyses after the construction of the dam across the Columbia River would be required. However, the long time required at low river flows for the water to pass through the pool above the Long Lake Dam and possibly also through the pool above the Columbia River Dam will constitute a considerable barrier against the passage of b.coli to the irrigating areas. The danger of specific b. coli pollution of irrigation water will be greater during periods of high flow. I do not regard this as an important factor at the present time, but the threat might cause an uneasiness amongst irrigators and to this extent is an influence in the direction of the installation of sewage treatment works.

D - PROJECTS FOR RELIEF OF POLLUTION

D-1. GENERAL STATEMENT

The sewage of Spokane and its environs results in an undesirable bacterial pollution of the river below the City, at times reduces the dissolved oxygen to a point approaching desirable minimums, causes visual pollution and tends to the formation of sludge deposits in the pools behind the dams. The relief of the river from this pollution calls for the following steps:

a. The concentration of the sewage at one or more convenient points for the application of chlorine by which to disinfect the sewage.

b. The removal of a substantial portion of the suspended solids so as to permit effective chlorination and to remove enough suspended matter to prevent the formation of sludge deposits and at the same time to eliminate visual pollution.

c. A sufficient reduction of the biological oxygen demand to remove the threat of lowering the dissolved oxygen in the river below desired limits of saturation.

The best procedure for accomplishing these objectives is the concentration of the sewage by intercepting sewers at a single point and the treatment of the sewage by clarification in settling tanks and appurtenances with provision for disinfection by liquid chlorine. The cost of intercepting sewers can be reduced by construction of two or three treatment plants close to the City and to the source of the sewage and these alternates are discussed in following sections. We do not believe that such alternates will be as satisfactory in the long run from an operating point of view as a single treat-

ment plant of the sedimentation type. More complete treatment of the sewage through biological or other processes is not necessary at the present time on account of the relatively well sustained river flow, although the hydraulics of a sewage disposal system should be planned to permit the addition of more treatment structures should standards of river cleaning advance in the future sufficiently to require them. Sedimentation of sewage will remove from 55 to 65 percent of the total suspended solids and practically all of the settling suspended solids in the raw sewage; and from 30 to 35 percent of the 5-day B.O.D. Fine screens will not remove over 10 percent of the total suspended solids although they will remove the coarser material, and some 5 to 10 percent of the oxygen demand. Screens would thus materially restrict visual pollution, but would not prevent the likelihood of sludge deposits. It will require more chlorine for the disinfection of a screening plant than of a settling plant effluent.

Projects for the relief of pollution thus require the construction of intercepting sewers, intercepting devices, river crossings, treatment works and probably one or two small district sewage pumping stations which are not indicated as being required at the present time.

Intercepting devices are built at the junction of the intercepting sewer with existing sewers and are designed to divert the dry weather flow and the first flush of storm sewage to the intercepting sewer; and to automatically by-pass flows in excess of a predetermined quantity to an outlet for

over-flow to the river. Intercepting devices include over-flow diversion weirs, orifices, float regulated gates and the like, the best for any location depending upon the range of flow, available head and the like. Inverted syphons are very often used for river crossings and have been satisfactory in operation where properly designed. Sufficient head is required to permit scouring velocities and blow-offs for drainage with ready access to the interior of the pipe are desirable features.

For all of these structures there is ample head available from the up-stream to the down-stream part of Spokane (Figure 9).

D-2. PROCEDURE FOR SOLVING THE PROBLEM

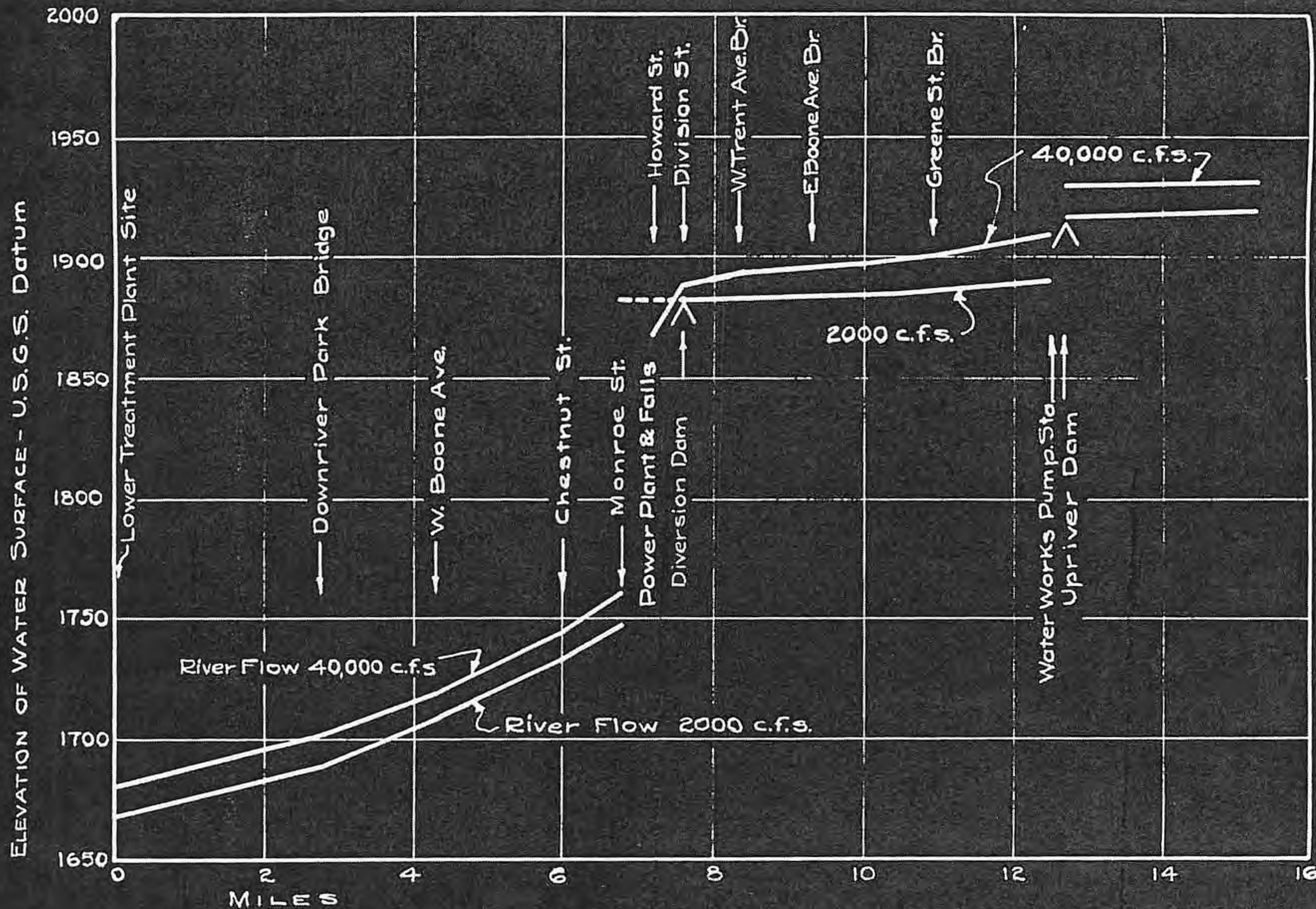
To determine the character and size of sewage disposal works as a whole, the following factors must be considered:

a. The population for which it is advisable to provide capacity.

b. The quantity of sewage likely to be produced by this population and for which capacity must be provided.

c. The characteristics of the sewage for which treatment works are to be built. Some sewages are stronger or more concentrated than others and in given cases industrial sewages produce special characteristics.

d. The capacity of the body of water into which the sewage is discharged to assimilate the treated sewage, and the uses to which the river water is put. This is a factor calling for considerable thought because the extent of sewage treatment works and the cost is largely determined by this factor.



PEARSE, GREELEY & HANSEN
HYDRAULIC & SANITARY ENGINEERS
6 NORTH MICHIGAN AVENUE
CHICAGO ILLINOIS

SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
PROFILE OF RIVER
THROUGH CITY
JULY 1933

FIG. 9

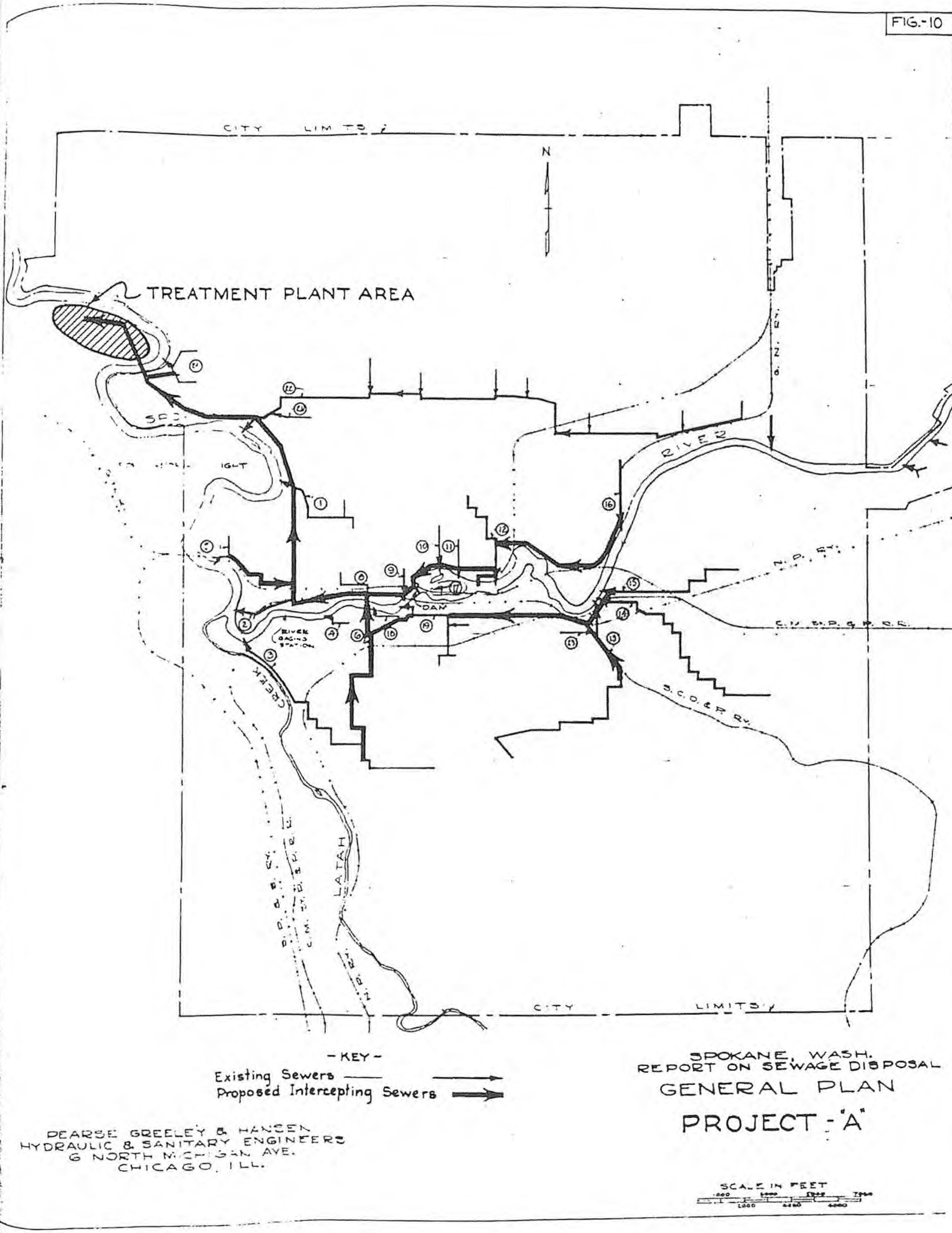
The solution of these factors is fundamental to the design of sewage disposal works. There are, however, other factors of importance; in particular, construction costs and methods of financing sewage disposal projects at the present time.

D-3. SITES FOR SEWAGE TREATMENT

The main outlines of a sewage disposal project are largely determined by available sites. (See general plans, Figures 10 and 11). No sites entirely removed from dwellings are available within easy reach at Spokane. The most favorable site, designated as the "A Site" is located south of the river and down-stream of the built-up portions of Ft. Wright. This site is suitable from many points of view, and with reasonable precautions for odor control in the design, should be entirely satisfactory for a sedimentation plant (or activated sludge).

Several smaller sites are available along the river through the City. The first of these is near the outlet of the Trent Avenue sewer in the vicinity of the gas works on the south side of the river. The second one is on the north side of the river where it bends sharply to the north about opposite the mough ot Hangman's Creek. This site is larger than the others. The third site is on the east side of the river near A Street extended. These three sites would be suitable for the installation of fine screening plants. I consider them too close to dwellings for the operation of sedimentation plants with the drying of sludge

FIG.-10



SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
GENERAL PLAN
PROJECT - "A"

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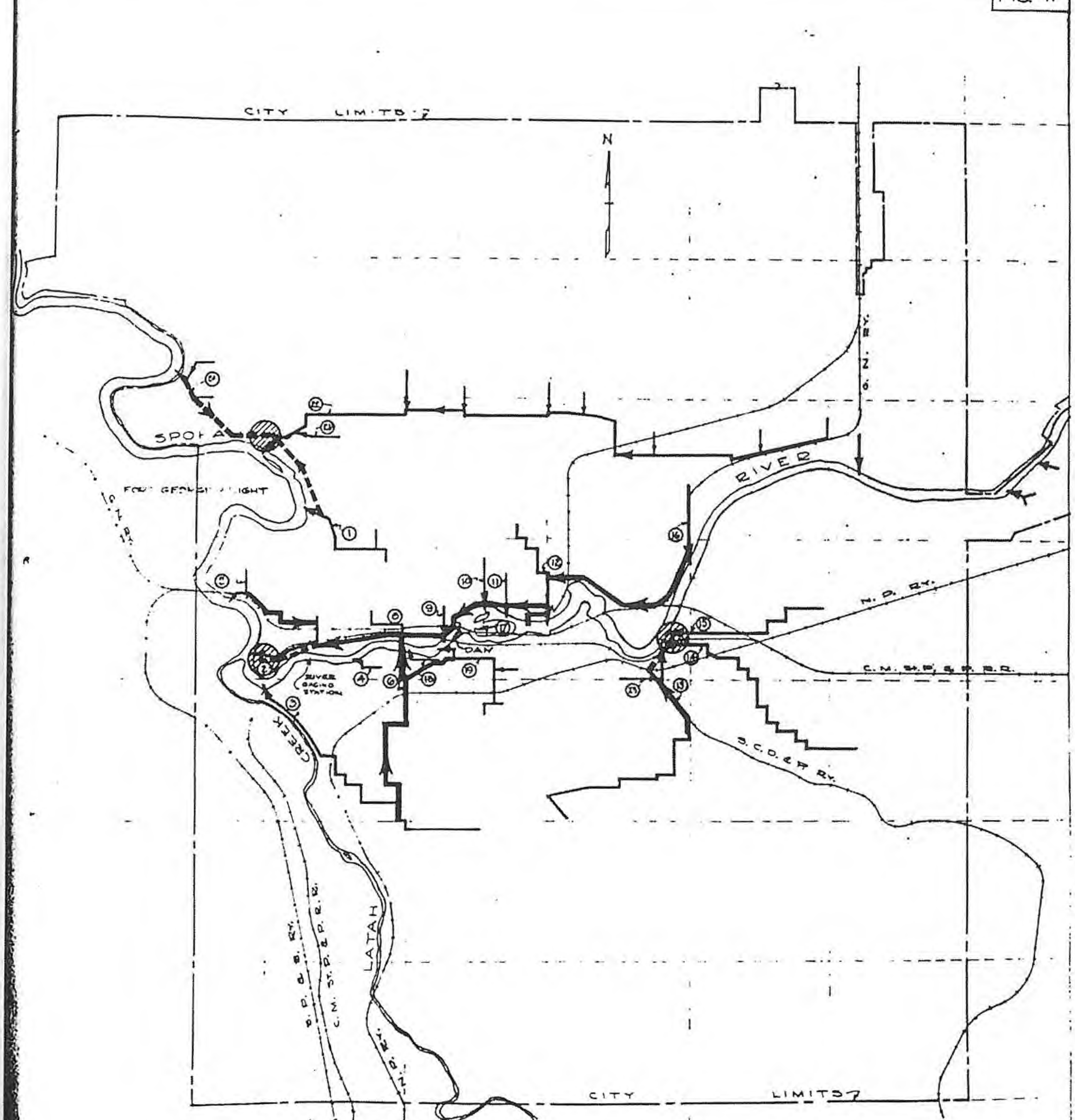
HYDRAULIC & SANITARY ENGINEERS
6 NORTH MICHIGAN AVE.
CHICAGO, ILL.

FIG.-11



-KEY-

Proposed Intercepting Sewers {Common to Projects "A" & "B" / Project "B" only

Existing Sewers

Screening Plant Sites

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CHICAGO, ILL.

SPOKANE, WASH.
REPORT ON SEWAGE DISPOSAL
GENERAL PLAN
PROJECT-"B"

SCALE IN FEET

on open beds. There is sufficient space for sedimentation and digestion tanks at the site opposite Hangman's Creek, but the sludge would have to be handled other than on open beds. This site, however, is of limited area and has not sufficient space for future complete treatment works. One method would be by mechanical de-watering of raw sludge on vacuum filters, and another by pumping the sludge to some distant point for digestion and open air drying, as for instance, to Site A.

D-4. GENERAL DESCRIPTION OF PROJECTS

The desirable project indicated for Spokane and designated as the A Project comprises a system of intercepting sewers delivering the sewage to Site A below Ft. Wright, and the construction of a plant for sedimentation and chlorination. Another group of projects, designated as the B projects is related to the use of two or three of the up-river sites. One of the B projects comprises screening and disinfection and another includes a sedimentation plant at the middle site opposite Hangman's Creek with chlorination of the sewage and mechanical dewatering of the sludge. In making up estimates of cost of sewage treatment works, we have included coarse screens, grit chambers, Venturi meters and similar appurtenances for all of the projects in addition to the main treatment units of settling tanks or fine screens.

For the sedimentation project, the displacement period in the settling tanks is taken at 2.0 hours for a yearly average basis of design flow of 22.0 million gallons

per 24 hours. The tanks are of the type that is equipped with mechanisms for the daily removal of sludge and separate digestion tanks are included. A general diagrammatic outline of the treatment plant at the A Site is shown in Figure 12. The final disposal of air dried digested sludge from settling tanks may be by dumping on available low ground or to farmers and gardners for use as a fertilizer.

For the fine-screening projects, the disposal of screenings would be first by pressing out some of the water, and then by delivering them to the present crematory for incineration. The average amount of finer screenings after pressing is indicated as about 4.0 tons per day with a moisture content of 70 percent, and this, we understand, will not overload the present crematory. We have included in the estimates of cost a press at the upper screening plant (near Trent Avenue) as this is closest to the crematory, and we have also included a truck for conveying the screenings from the other two plants to this point for pressing, and to the crematory.

D-5. COMMENTS ON INTERCEPTING SEWERS

Preliminary plans and estimates of cost of intercepting sewers have been prepared by the City Engineer. (Figures 10 and 11). For Project A there are two main intercepting sewers. One intercepts existing sewers along the south side of the river and discharges into the other or north side interceptor through a river crossing at Cedar Street. A considerable amount of tunnel work will be required, as, for

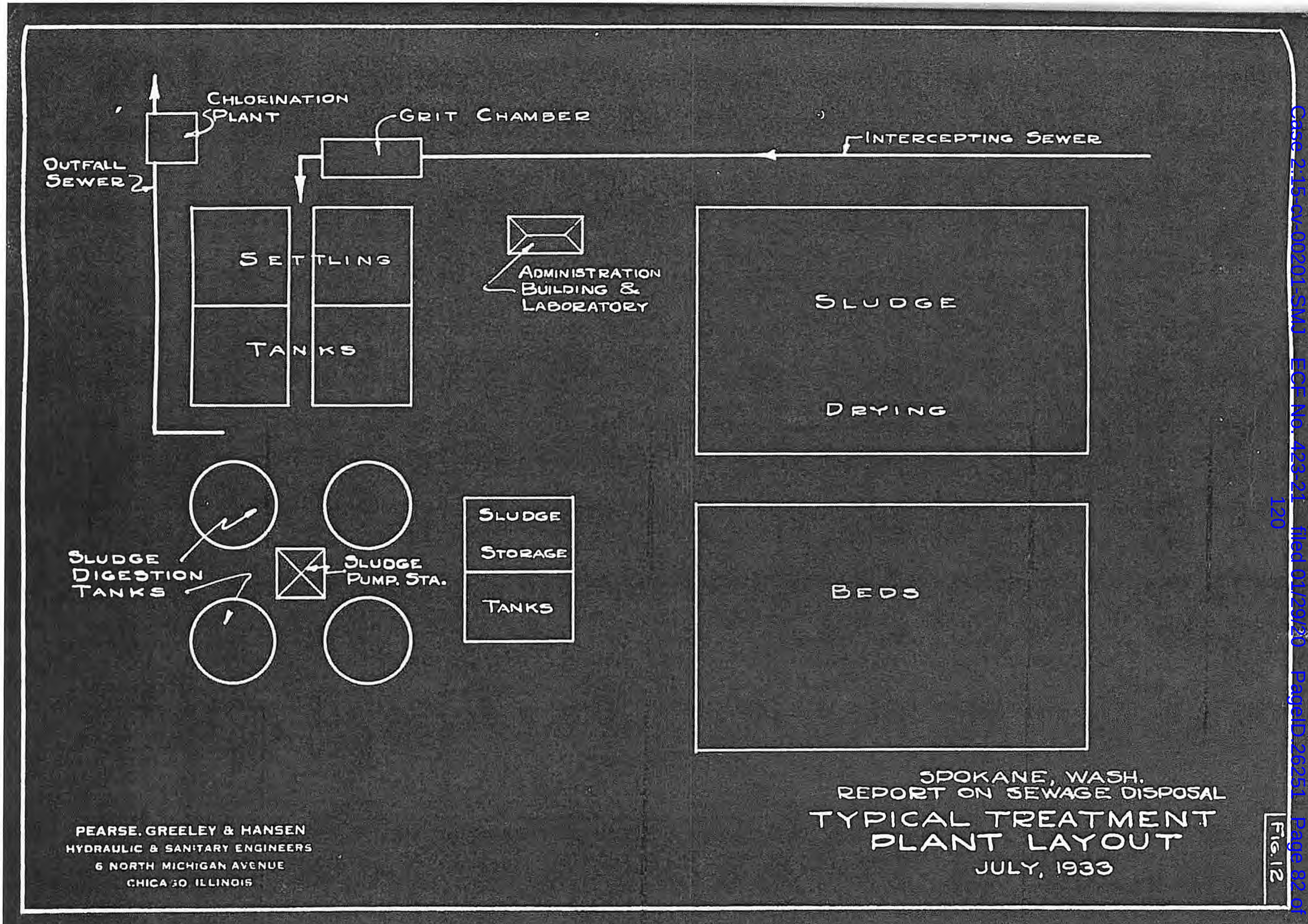
Fig. 12
Chlorination Plant
Grit Chamber
Intercepting Sewer
Outfall Sewer
Settling Tanks
Administration Building & Laboratory
Sludge Drying Beds
Sludge Digestion Tanks
Sludge Pump. Sta.
Sludge Storage Tanks
Spokane, Wash.
Report on Sewage Disposal
Typical Treatment Plant Layout
July, 1933
Pearse, Greeley & Hansen
Hydraulic & Sanitary Engineers
6 North Michigan Avenue
Chicago Illinois

instance, paralleling Main Avenue from Brown to Hatch Streets, and along Nettleton Street north of the river. A river crossing about opposite Fort Wright is also included.

The intercepting sewers for the screening plants are of smaller size and shorter length than in the A Projects and thus, are lower in first cost. With three sites developed, the sewer along Main Street on the south side of the river would not be required and there would be some other differences of a minor sort.

An alternate and somewhat intermediate project comprises settling tanks with mechanical sludge de-watering or pumping of raw sludge to digestion tanks at Site A. The estimated cost of intercepting sewers is higher than for three screening plants. Up to Nettleton Street, the sizes and alignment would be about the same as in Project A.

Time has not permitted a detailed study of the hydraulics of the intercepting sewer systems, nor does this appear necessary in a preliminary consideration of the problem. Careful consideration should be given to the capacity of the intercepting sewers throughout their length so that reasonable quantities of sewage will be intercepted and the amount by-passed to the river properly controlled. Present computations indicate a capacity in the intercepting sewer at its lower end of somewhat over 100 million gallons per 24 hours. For an estimated future population taken as a basis of design for intercepting sewers of 250,000, this is equivalent to an ultimate intercepting sewer capacity of

some 400 gallons per capita per 24 hours. This is indicated by the data in Table 7 as a not unreasonable unit quantity for use as a basis for the design of intercepting sewers. Due consideration should be given to a distribution of future sewage quantities from the smaller up-stream areas to the larger areas down-stream, and to the various other details of the intercepting sewer project.

An estimate of cost of the intercepting sewer for Project A and B has been prepared by the City Engineer, and we have reviewed and discussed these costs with him. We have computed an estimated cost for the intermediate project from these two. As a result the total estimated cost of the intercepting sewers, including all apprutenances and an allowance for engineering and contingencies, is estimated as follows:

Project A	$1,100,000
Intermediate Project	815,000
Project B	500,000

The unit prices per foot of sewer used in computing these estimates, I believe to be reasonably conservative and to allow some margin for an increase in recent construction costs.

D-6. TREATMENT PLANT LOADINGS

Although the time available has not permitted a final determination of the loadings of all the elements of a sewage treatment plant, the following summarizes the allowances which have been made in computing estimates of cost for the larger structures. These allowances are

TABLE 7

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Comparative Data on Intercepting Sewer Capacities

Place	Average Dry Weather Sewage Flow	Intercepting Cap., Date of Ultimate Design Gallons per Capita per day
Minneapolis-St. Paul, Metropolitan Drainage Commission (Contemplated)		
Interceptor "A"	* 140	389
Interceptor "B"	* 197	520
Interceptor "C"	* 142	422
Interceptor "D"	* 158	472
Interceptor "D_1"	* 156	434
Rochester	120	420
Detroit	155	329
Syracuse	187	314
Milwaukee	150	364
Louisville Bear Grass Creek	146	412
Kansas City Blue River	100	378
Decatur at Treatment Plant		457
Springfield at Treatment Plant		397
Cincinnati	175	366
Des Plaines	125	260
Cleveland	135	405
Albany	200	450
Fitchburg		445

NOTE: * Total average domestic sewage and commercial and industrial wastes plus one-half quantities added for wet season flows.

believed to be safe and on the whole rather ample than otherwise for making up preliminary computations.

a. Actual human population connected - 100,000

b. Yearly average human sewage, - 20.0 M.G.D. to which has been added 2.0 M.G.D. for industrial sewage.

c. Grit chambers with mechanical removal and washing of grit.

d. The settling tanks provide a displacement period of 2.0 hours with a sewage flow of 22.0 M.G.D.

e. Heated sludge digestion tanks with provision for control are included with a total capacity of 210,000 cubic feet, equivalent to 2.1 cubic feet per capita. This is a somewhat high per capita allowance, but includes capacity for the industrial sewage.

f. Sludge storage tanks provide 150,000 cubic feet, equivalent to 1.5 cubic feet per capita, and are intended to store digested sludge during seasons when the sludge cannot be dried on open beds.

g. Sludge drying beds have an area of 125,000 square feet.

The various necessary appurtenances are also included as, for instance, sludge pumps, heating plant, meters, water supply, outside piping, office building, and the like. In the B Projects, fine screens have been proposed with 1/16 inch slots or clear openings.

D-7. ESTIMATED COST OF SEDIMENTATION PLANT

The estimated construction cost of a sedimentation plant at the A Site is given in Table 8. The cost of the larger structures is computed on the basis of actual construction costs of similar projects adjusted to local costs

TABLE 8

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Cost Estimate for Sedimentation Plant at Downstream Site

Item	Cost
Coarse Screen, Grit Chamber, Inlet Connections	$ 25,000
Venturi Meter	6,500
Primary Settling Tanks	100,000
Sludge Digestion Tanks	70,000
Sludge Pumping Station, Heating Plant, etc.	30,000
Sludge Storage Tanks	22,500
Sludge Drying Beds	40,000
Office Building	16,000
Outside Piping, Fence, Roads, Etc.	45,000
Chlorination Plant	20,000
	$375,000
Engineering & Contingencies	45,000
	$420,000
Land	10,000
Allowance for Hauling to Site	20,000
	$450,000

of labor and materials and with some little allowance for a possible increase in unit costs over those of the last few months. The cost of tanks is computed from a unit price per cubic foot of liquid volume, of sludge beds per square foot of area, and of other structures more or less on a capacity basis related to similar structures at other plants.

The estimated annual cost of operation (exclusive of fixed charges) is as follows:

Item	Annual Cost
General Overhead	$ 500
Superintendent & chemist	3,000
Laboratory Assistant	1,200
Chief Operator	2,000
Operators (4 @ $125)	6,000
Sludge pumping (1 man)	1,500
Additional Labor	3,000
Repairs & Supplies	4,000
Chlorine @ 80¢ per M.G. and 2½¢ per lb. applied 4 months of the year	4,300
	$25,500

The labor schedule is based on experience in a number of other plants of similar size and type. An item is included for liquid chlorine for disinfection for four months of the year. No allowance is made for power as it has been assumed that an ample amount will be available from the sludge gas. The operating cost is related to an average yearly flow

of 18.0 M.G.D. and is the cost which will prevail during early years of operation. It will not, however, increase to any great extent until additional units are required to be built.

D-8. ESTIMATED COST OF SCREENING PLANTS

An estimated cost has been made for the installation of fine screening plants at an upper site near Trent Avenue, at a middle site opposite Hangman's Creek and at a lower site opposite A Street extended. Each of these installations includes the following major structures:

Inlet connections

Coarse bar screens

Grit chambers

Measuring Devices

Fine screens

Contact tank and chlorinator

Buildings with space for office and small laboratory

Outside piping

Water supply

Roads and fences

No very elaborate or ornamental buildings are proposed. The plant at the upper site includes a press for dewatering fine screenings from all of the three plants. It is estimated that the amount of fine screenings dewatered to 70 percent of moisture will amount to about 4.0 tons per 24 hours. No allowance is made in the first cost for a truck,

but its rental is included in the operating costs. Including an allowance of $10,000 for land and of about 12.5 percent for engineering and contingencies, the estimated cost of these three screening plants, comprising the B Project is $250,000.

The estimated annual cost of operation is as follows:

Item	Annual Operating Cost
General overhead	$ 500
Superintendent	2,400
Chemical analyses	1,000
Operators (5 men)	7,500
Truck and driver	3,600
Repairs and supplies	5,000
Transportation	2,000
Chlorine at 100¢ per M.G.	5,500
	$27,500

D-9. ALTERNATE PROJECTS

We have given some consideration to the possible installation of a sedimentation project at the Middle Site opposite Hangman's Creek on the basis of dewatering the raw sludge by vacuum filters or some equivalent mechanical method and of incinerating the dewatered sludge. The average amount of dewatered sludge containing 65 percent of moisture is estimated to be about 32.0 tons per 24 hours on the basis of dewatering raw sludge. Such a sedimentation plant would comprise the major clarification elements of the A Project, but would not

include digestion tanks, sludge drying beds and related appurtenances. In their place would be a mechanical sludge dewatering plant and an incinerator. The total estimated construction cost of this project is about $350,000 as compared to an estimated cost of $450,000 for the plant with sludge digestion and open sludge drying beds. The site is not favorable for the operation of an incinerator.

The annual cost of operation for this type of sedimentation plant is higher than where the sludge is digested and dried on open beds. One item of additional cost is the chemicals which must be added to the sludge to facilitate the dewatering. There is also an additional item required for the incineration of the sludge. While this item is somewhat uncertain because there may be some demand for the dewatered sludge as a fertilizer, we have allowed a sufficient amount to provide for its incineration. On the foregoing bases, we estimate the annual cost of operation of a project of this type at about $48,000 per year. This, of course, is relatively high and indicates that this type of project is not applicable under conditions at Spokane.

Another alternate would include the substitution of sludge pumps and a force main and the construction of digestion tanks and open sludge drying beds at the A Site below Fort Wright. This would add to the estimated cost of the sedimentation plant at the A Site of $450,000 an amount of about $50,000 for a sludge pumping station and force main, making a total of some $500,000. There would be also some

additional cost over the estimated annual operating cost of the sedimentation plant because of operations at two points and the cost of pumping the sludge. We estimate this additional labor and power at about $5,000 per year.

Another alternate would be the construction of intercepting sewers to deliver sewage from up-stream and adjacent sewers to the Middle Site opposite Hangman's Creek, where a screening plant would be installed, with a smaller screening plant at the site opposite A Street extended, the project thus comprising two screening plants. On the basis of cost, this project is not as favorable as the one comprising three screening plants.

D-10. COMPARISON OF TOTAL PROJECT COSTS

The total cost of sewage disposal projects will include both the intercepting sewers and the sewage treatment plants. The total annual cost will include operating costs and fixed charges. We have computed fixed charges on the basis of a Federal grant amounting to 25 percent of the total estimated costs and a loan for the remaining 75 percent at an interest rate of 4 percent. On these assumptions, the total construction costs and annual costs of the various projects are summarized in Table 9.

D-11. COMMENTS ON COMPLETE TREATMENT

At the present time there is no need for a complete treatment of the sewage. It would add materially to the construction and total annual costs. We have not, therefore, made

TABLE 8

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Total Costs of Various Projects

Item	Sedimentation			Screening at Three Sites
	Downstream Site	Middle Site with Sludge Filtering (1)	Middle Site with Sludge Pumping (1)	
Construction Costs:				
Intercepting Sewers	$1,100,000	$ 815,000	$ 815,000	$500,000
Treatment Works	450,000	350,000	500,000	250,000
TOTAL	$1,550,000	$1,165,000	$1,315,000	$750,000
Portion paid by City at 75% of Total	$1,160,000	$ 865,000	$ 985,000	$562,000
Fixed Charges at 6%	69,500	51,800	59,200	33,700
Operating Costs	25,500	48,000	30,500	27,500
TOTAL ANNUAL COST	$95,000	$99,800	$89,700	$61,200

NOTE: (1) A desirable addition to these projects would be buildings over the settling tanks which would add about $50,000 the the construction cost and $2,150 to the annual cost.

any detailed estimate. Experience in other places has indicated that a complete treatment plant of the activated sludge type with a capacity for 100,000 population and a sewage flow of 22.0 M.G.D. with some allowance for the additional strength of the sewage on account of the industrial wastes will cost perhaps $1,000,000, depending upon the amount of pollution load added by the industries. This estimate is for the complete plant including sedimentation, aeration, sludge disposal and appurtenances, and is not an additional amount to the estimated cost of a sedimentation plant under the A Project.

D-12. COMMENTS ON INDUSTRIAL SEWAGES

The major industrial sewages come from the five packing houses. They increase the strength of the sewage by increasing the suspended matter and the biological oxygen demand. The strength of packing house sewages depends to a considerable extent upon the operations at the packing houses. The disposal of paunch manure by the packing houses is an important item. Most packing houses operate grease recovery basins and if these are ample and well operated, the strength of the packing house sewage is somewhat reduced. In some cases, where sewage treatment works have been installed, packing houses have built fine screens in order to take some of the coarser suspended matter out of the sewage and thus relieve the load upon the sewage treatment plant. In some few cases as at Fort Worth, Texas, the packing houses have also built and operated settling tanks to further reduce the

load upon the treatment plant. Time has not permitted a close scrutiny of this item. With the sewage treatment limited to clarification, the effect of moderate sewage treatment at the packing houses is not so important an item as with complete treatment. It would be desirable to have this matter in mind particularly as operating experience develops at the treatment plant. In general, the strength of the packing house sewage should be limited by reasonable treatment at the packing houses including in the first instance the retention and disposal of paunch manure and the operation of grease basins, with a further screening of the packing house sewage, should that be found desirable to facilitate the operation of sludge handling works at the sewage treatment plant. It is generally necessary to maintain control by the City over the discharge of industrial sewage into the intercepting sewers. Occasionally toxic wastes have to be eliminated and otherwise disposed of and any overloading of reasonable sewage treatment plant capacities should be avoided.

D-13. RESULTS FROM EACH PROJECT

The best results from operation as regards the cleaning of the river and the removal of sewage from the City will be secured by the installation of the A Project. This will remove sewage from the river through the City, will take out practically all of the settling suspended solids and thus prevent the formation of sludge deposits and will provide the removal of bacterial pollution on a satisfactory basis. The construction of a similar plant at the Middle Site opposite

Hangman's Creek with sludge digestion and drying at the a site below Fort Wright will accomplish about the same result except that the sewage effluent will have some travel through a stretch of the river within the city limits. Treatment of the sewage by screening will to a large extent remove visual pollution and will permit of adequate disinfection, although a larger amount of chlorine will be required. The settling suspended solids will not be sufficiently reduced to prevent the formation of sludge deposits and the reduction in the oxygen demand will be very limited. There will also be a continued discharge of sewage effluent into the river through the City and in particular in the stretch above the diversion dam at Monroe Street.

Appendix I

[illegible]

APPENDIX 1

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Description of Sewer Districts

- - - - -

CITY OF SPOKANE

Spokane, Washington
July 12, 1933

Mr. Samuel A. Greeley
6 North Michigan Avenue
Chicago, Illinois

Dear Mr. Greeley:

This is supplementing my letter of last night, and if you will refer to your colored map, on which the sewer districts and the numbers indicating the sewer outlets are shown in different shades of color, it will aid you in following the descriptions.

No. 1. This drains a purely residence section of the city quite completely served by sewers.

No. 2. At the present time this serves a very limited amount of residence district by reason of the fact that the O. W. R. & N. Co.'s shops occupy such a large portion of the district. The railroad was put through after the sewer was installed and cut off some of the residence district that previously drained into this sewer. It carries only the sanitary sewage and such drainage as would come from the flushing of boilers and such uses as water is put to around such shops.

No. 3. This takes the drainage from the Cannon Hill district and Cannon Hill Park area. This is situated on the hill section of the city, and built up with the better class of residences. It is the plan, with the new intercepting sewer, to cut off a large amount of the area that now drains into this sewer and carry it directly north on Maple Street and Cedar Street, connecting up with the main interceptor at Cedar Street and Riverside Avenue. This would leave only about 100 acres and 325 house connections contributing to this trunk sewer. If in the future it was thought best to treat this sewage, it could be done either by pumping into the intercepting sewer across the river or by the installation of a separate treating plant at the junction of Latah Creek and the Spokane River.

No. 4. and No. 7. These are outlets from sewers draining a very limited area, their combined area being about 40 acres. These sewers outlet into the river at a low level and most of the territory which they drain is only slightly above the high-water elevation of the river. You will recollect that this is the place where we stopped and talked to a fisherman who had caught several good-sized squaw fish and suckers.

No. 5. This is a sewer draining a residence district including one large hospital, the St. Luke's.

No. 6. This is the sewer outlet which drains the older residence district of Browne's Addition and a part of Cannon Hill, some of which has now been given over to apartment houses and hotels. The eastern section of this district is occupied by automobile salesrooms and store buildings.

No. 8. This serves the same character of district as No. 1, 2 and 5, with the exception that there are a few apartment houses interspersed among the private dwellings.

No. 9. This drains a small area which has of recent years grown up to business and apartment houses.

No. 10 and 11. These serve districts which embrace quite a good deal of property which is at present undeveloped. By reason of the fact that this territory is close to the center of the city, it will probably be improved as business or light industry. At the outlet of No. 10, we have the connection from the Centennial Flour Mill, which as I indicated in yesterday's letter, has a capacity of about 1000 barrels.

No. 12. This serves a large, flat residence section on the north side of the city and a limited area along Division Street devoted to stores, warehouses, etc. One wheat storage plant washes approximately 135,000 bushels of wheat a year and uses 2,697,750 gallons of water a year.

No. 13. This sewer carries the largest quantity and the most dilute of any of the sewers at present on the south side of the river. It takes in the Manito, Rockwood and Liberty Park districts, which are a very good class of residence districts. It also drains a small industrial area including the Sperry Flour Mill and a few small factories. The reason for the dilute sewage is that there is considerable ground water in the area which this sewer drains and a great deal of this water finds it way into the sewer. In the southeastern section of this district there are approximately 440 acres of undeveloped territory.

No. 14. This drainage area at present embraces a residence district in the flat, prairie section of the city, lying to

the southeast. Eventually this district will be increased in size very materially, and will take in the Lincoln Heights and South Altamont districts, each being residence districts largely of small, single family dwellings. In the southeastern section of this district there are 1660 acres of very sparsely settled territory, some of which is entirely undeveloped.

No. 15. This is a sewer which takes the drainage from the Carstens and Armour packing plants, and it carries by far the most concentrated sewage of any in the city. There is a residence district also tributary to this same sewer, but at present there are only 58 house connections leading into it. This section of the city has been largely given over to industry and its future development will probably along that line. Lying to the north and east of this territory is a considerable area, approximately 700 acres, for which no privision has been made for sewers. The western section of this area is sparsely settled, and the eastern section is largely undeveloped. There is a probability, in case this section of the city should develop to a great extent and furnish more sewage than the interceptor could take care of, a separate treatment plant might be installed at some central place along the Spokane River. The interceptor capacity beginning at Erie Street near the gas works, however, should be sufficient to take care of any reasonable development of this area. It is the thought in connection with this sewer that the entire capacity of this trunk sewer would be provided for in the interceptor.

No. 16. The area draining into this sewer is built up by the ordinary residence district which is common to the north side of the city.

No. 17. This is a small sewer furnishing drainage for the property on Havermale Island, the large island on which the Great Northern depot is located.

No. 18. This serves only a limited area, and is of very little consequence so far as its outlet is concerned because of the fact that if the interceptor is installed it will take care of practically everything that now reaches this sewer.

No. 19. This is the 66-inch trunk sewer which drains almost the entire downtown section of the city and takes in most of the hotel and apartment house district on the south side of the river. There are several creameries and a number of wholesale establishments in this district.

No. 21. This drains a small north side residence district.

No. 22. This is the largest sewer in the city and drains the largest part of the north side. Although its flow is comparatively small, there are 2724 house connections made to this sewer and its laterals.

No. 23. This serves a small district which drains into No. 13, below the place where No. 13 is gauged. It consists of a very sparsely settled residence section.

No. 24. This drains one of the newer north side residence sections of the city, emptying into the Spokane River near the golf course.

This is a brief sketch of the character of the various districts, and if there is any additional information concerning any one of these which you wish, kindly let me know and I will amplify the description.

Yours truly,

(Signed) A. D. Butler
City Engineer

ADB-mrh

Appendix 2

APPENDIX 2

APPENDIX 2

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Average Discharge for All (22) Sewer Outlets

24 Hour Period

	Sewer Outlet	Average Discharge Cubic Feet per Second	
1	Nora and R. R.	0.86 *	
2	Summit and Lindeke	0.25	
3	Riverside and A	0.68 *	
4	Elm and Main	0.30	
5	Summit and Sherwood	0.10	
6	Cedar and Clarke	1.71 *	
7	Main and Ash	0.25	
8	Cedar and Ide	0.16	
9	Monroe and Bridge	0.20	
10	Howard St. N.	0.25	
11	Washington St. N.	0.25	
12	Division St. N.	0.97 *	
13	Front and Ivory	4.60 *	
14	Front and Denver	0.53	
15	Trent and Denver	2.36 *	
16	Sharp and River	0.60	
17	Howard St. S.	0.07	
18	Main and Wright	0.65	
19	Lincoln and Trent	5.27 *	
22	Cochran	0.75 *	Weir Measurement
23	Sprague and Arthur	0.75	
24	Columbia Circle	0.15	
	Total Average	21.71 C.F.S.	

NOTE:

* Indicates sewer outlets at which samples were taken for chemical analysis, and at which measurements of flow were taken for a greater period of time than from other outlets. The flow from these 8 outlets is 80% of the total average flow.

Appendix 3

APPENDIX B

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Analysis of 24 hour Composite Sewage Samples

Sewer Outlet		Date 1933	Flow (Cu. Ft. / Second) Min.	Max.	Aver.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 1	Nora and R. R.	May 3	0.45	1.02	0.74	278	129	97	.280	
	" " "	" 12	0.81	1.29	0.99	361	152	125	.450	7.1
	" " "	" 15				215	130	120		7.3
	" " "	" 17	0.67	1.14	0.84	162	167	115	.430	6.9
	" " "	" 18				111	152	107	1.300	7.0
	" " "	" 20				141	200	100		6.9
Average						211	155			
No. 3	Riverside & "A"	Apr. 29	0.25	1.20	0.76	253	298	184		7.3
	" "	May 4	0.30	1.36	0.71	878	239	206	.920	6.8
	" "	" 11	0.30	0.85	0.52	231	211	178	.460	7.3
	" "	" 12				90	140	115	.450	7.1
	" "	" 13				135				7.1
	" "	" 17	0.55	1.15	0.73	182	175	135	.350	7.1
	" "	" 18				171	263	185	.670	7.4
	" "	" 20				331	260	170		7.1
Average						284	227			
No. 6	Clarke and Cedar	Apr. 21		2.05		100				
	" "	" 29				352	209	161		6.9
	" "	May 4	0.58	2.90	1.78	572	210	166	1.100	7.0
	" "	" 11	0.90	2.10	1.49	331	207	184	1.500	7.0
	" "	" 12				400	225	175	.180	6.6
	" "	" 13				155	380	350		6.9
	" "	" 17	1.20	3.20	1.75	312	250	190	3.800	7.1
	" "	" 18				241	200	155	5.200	6.8
	" "	" 20				271	270	220		6.8
Average						304	244			

APPENDIX (Continued)

Sewer Outlet	Date 1933	Flow (Cu.Ft. / Second) Min.	Max.	Aver.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 12 Division St.	Apr. 28				332	178	143	.820	
" "	May 5	0.35	1.28	.96	247	238	206	.600	7.1
" "	" 12	0.58	1.38	.96	150	175	133	.980	7.1
" "	" 13				462	260	210		6.8
" "	" 17				332	140	120	1.500	6.9
" "	" 18	0.35	1.65	0.99	321	335	225	1.300	6.8
" "	" 20				251	240	190		7.1
Average					299	224			
No. 13 Inland R. R.	Apr. 27				36	66	58	.180	
"	May 6				75	57	49		7.3
"	" 12	3.20	5.50	4.66		105	95	.160	7.3
"	" 13				75	90	70		7.3
"	" 17	3.90	5.24	4.55	92	105	85	.330	7.2
"	" 18				31	96	66	.190	7.3
"	" 20				71	110	80		7.1
Average					63	90			
No. 15 Trent Avenue	May 6	1.44	3.30	2.12	1200				6.8
" "	" 12	1.70	2.65	2.43	811	505	455	1.900	6.8
" "	" 17	1.92	3.10	2.53	742	390	340	8.000	6.7
" "	" 18				1202	520	450	14.000	6.6
" "	" 20				1442	590	510		6.7
Average					1079	501			
No. 19 Lincoln St.	Apr. 28				132	111	88	1.300	
" "	May 5	4.10	6.60	5.37	112	171	142	.850	7.3
" "	" 12	3.80	5.50	4.74	20	128	120	1.600	7.1
" "	" 13				145	150	130		7.1
" "	" 17				162	135	110	2.300	7.0
" "	" 18	4.10	7.85	5.70	71	152	95	1.200	7.0
" "	" 20				116	110	80		6.9
Average					108	137			

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APPENDIX 3 (Continued)

Sewer Outlet	Date 1933	Flow (Cu.Ft./Second) Min.	Max.	Aver.	Oxygen Demand P.P.M.	Susp- Solids p.p.m.	Vola- tile Solids	Bact- erial Count	pH
No. 22 Cochran St.	May 3	3.5	5.7	5.14	381	247	201	.310	7.5
" "	" 10	4.5	5.7	5.54	381	309	235	1.500	7.3
" "	" 12				360	378	295	1.600	7.2
" "	" 13				282	390	320		7.1
" "	" 17	4.8	5.4	5.25	362	360	255	.240	7.2
" "	" 18				291	343	273	2.600	7.1
" "	" 20				261	430	220		7.1
Average					331	351			
Composite of above 8 Samples	May 12				210	300	245	1.100	7.1
	" 13				222	210	200		7.1
	" 17				232	190	140	1.400	7.1
	" 18				231	205	180	2.600	7.1
	" 20				261	200	130		7.0
Average					231	221			

APPENDIX 3

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Analysis of Hourly Sewage Samples

Sewer Outlet	Date 1933	Hour	Flow C.F.S.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 1 Nora & R. R.	June 13	10 AM	1.20		170	130		
" " "	" 13	12 N	1.29		275	225		
" " "	" 13	2 PM	1.37		150	120		
" " "	" 13	4 PM	1.23		105	85		
Composite	" 13			262			.890	
No. 1 Nora & R. R.	" 14	10 AM	1.29		130	115		
" " "	" 14	12 N	1.20		110	100		
" " "	" 14	2 PM	1.14		95	80		
" " "	" 14	4 PM	1.14		85	65		
Composite	" 14			292			4.400	
No. 1 Nora & R. R.	" 15	10 AM	1.20		140	130		
" " "	" 15	12 N	1.20		135	110		
" " "	" 15	2 PM	1.02		90	80		
" " "	" 15	4 PM	1.20		150	140		
Composite	" 15			182				
No. 3 Riverside & A	" 13	10 AM	1.36		285	215		
" " "	" 13	12 N	1.15		365	230		
" " "	" 13	2 PM	1.15		285	230		
" " "	" 13	4 PM	1.85		115	100		
Composite	" 13			320			1.600	
No. 3 Riverside & A	" 14	10 AM	1.36		245	175		
" " "	" 14	12 N	1.36		230	190		
" " "	" 14	2 PM	1.15		185	145		
" " "	" 14	4 PM	1.15		130	100		
Composite	" 14			252			1.200	

APPENDIX B (Continued)

Sewer Outlet	Date 1933		Hour	Flow C.F.S.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 3 Riverside & A	June	15	10 AM	1.80		330	260		
" "	"	15	12 N	1.56		350	270		
" "	"	15	2 PM	1.15		230	200		
" "	"	15	4 PM	1.15			210		
Composite	"	15			292				
No. 6 Clarke & Cedar	"	13	10 AM	3.60		285	245		
" "	"	13	12 N	2.90		210	160		
" "	"	13	2 PM	2.90		335	295		
" "	"	13	4 PM	2.40		515			
Composite	"	13			532			3,000	
No. 6 Clarke & Cedar	"	14	10 AM	3.60		200	175		
" "	"	14	12 N	4.80		220	180		
" "	"	14	2 PM	3.60		190	95		
" "	"	14	4 PM	3.60		410	365		
Composite	"	14			282			6,000	
No. 6 Clarke & Cedars	"	15	10 AM	3.60		200	170		
" "	"	15	12 N	4.30		410	360		
" "	"	15	2 PM	4.30		215	180		
" "	"	15	4 PM	3.20		210	190		
Composite	"	15			292				
No. 12 Division Street	June	7	10 AM	1.38		205	175		
" "	"	7	12 N	1.28		280	235		
" "	"	7	2 PM	1.38		310	245		
" "	"	7	4 PM	1.16		65	60		
Composite	"	7			501			5,300	

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APPENDIX [illegible] (Continued)

Sewer Outlet	Date 1933	Hour	Flow C.F.S.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 12 Division Street	June 9	10 AM	1.28		240	170		
" "	" 9	12 N	1.16		230	175		
" "	" 9	2 PM	1.38		290	235		
" "	" 9	4 PM	1.38		200	160		
Composite	" 9			620				
No. 12 Division Street	" 12	10 AM	1.50		355	220		
" "	" 12	12 N	1.38		490	370		
" "	" 12	2 PM	1.50		410	315		
" "	" 12	4 PM	1.28		210	150		
Composite	" 12						2,400	
No. 13 Inland R. R.	June 7	10 AM	4.85		125	85		
"	" 7	12 N	4.62		325	115		
"	" 7	2 PM	4.85		65	60		
"	" 7	4 PM	4.40		55	50		
Composite	" 7			106			0.730	
No. 13 Inland R. R.	" 9	10 AM	4.62		40			
"	" 9	12 N	4.40		100			
"	" 9	2 PM	4.12		45			
"	" 9	4 PM	4.12		50			
Composite	" 9			101			0.480	
No. 13 Inland R. R.	" 12	10 AM	river		200	155		
"	" 12	12 N	back-		210	160		
"	" 12	2 PM	water		160	105		
"	" 12	4 PM			60			
Composite	" 12						0.520	
No. 15 Trent Avenue	May 23	8 AM	1.56		210	190		
" "	" 23	10 AM	2.15		240	200		
" "	" 23	12 N	2.32		580			
" "	" 23	2 PM	2.65		1180			
" "	" 23	4 PM	3.48		870			
" "	" 23	6 PM	1.70		410			
" "	" 23	8 PM	1.86		110			
Composite				1100				

APPENDIX 3 (Continued)

Sewer Outlet	Date 1933	Hour	Flow C.F.S.	Oxygen Demand p.p.m.	Suspd Solids p.p.m.	Vola-tile Solids	Bact-erial Count	pH
No. 15 Trent Avenue	May 24	8 AM	2.00		425			
" "	" 24	10 AM	2.32		1240			
" "	" 24	12 N	2.40		860			
" "	" 24	2 PM	2.50		380			
" "	" 24	4 PM	1.56		2640			
" "	" 24	6 PM	1.85		930			
" "	" 24	8 PM	1.85		118			
Composite	" 24			1504 +				
No. 15 Trent Avenue	" 25	8 AM	1.17		17			
" "	" 25	10 AM	1.70		470			
" "	" 25	12 N	2.00		1440			
" "	" 25	2 PM	2.84		240			
" "	" 25	4 PM	3.50		1450			
" "	" 25	6 PM	2.15		460			
" "	" 25	8 PM	1.85		148			
Composite	" 25			1094				
No. 15 Trent Avenue	" 26	8 AM	2.00		570			
" "	" 26	10 AM	2.25		850			
" "	" 26	12 N	2.65		440			
" "	" 26	2 PM	2.85		850			
" "	" 26	4 PM	4.42		860			
" "	" 26	6 PM	2.59		530			
" "	" 26	8 PM	2.15		268			
Composite	" 26			1500 +				
No. 19 Lincoln & Trent	June 1	8 AM	6.30		68			
" "	" 1	10 AM	6.00		237	117		
" "	" 1	12 N	6.80		103	76		
" "	" 1	2 PM	7.85		125	110		
" "	" 1	4 PM	6.00		224	189		
" "	" 1	6 PM	5.50		85	70		
Composite "	" 1			283				

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APPENDIX 5 (Continued)

Sewer Outlet	Date 1933	Hour	Flow C.F.S.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 19 Lincoln & Trent	June 2	8 AM	5.00		100	90		
" "	" 2	10 AM	6.60		162	150		
" "	" 2	12 N	6.80		110	100		
" "	" 2	2 PM	6.00		100	95		
" "	" 2	4 PM	6.00		75			
" "	" 2	6 PM	5.00		75			
Composite	" 2			152				
No. 19 Lincoln & Trent	" 5	8 AM						
" "	" 5	10 AM	7.35		170	160		
" "	" 5	12 N	5.50		130	120		
" "	" 5	2 PM	7.35		160	160		
" "	" 5	4 PM	6.00		115	105		
" "	" 5	6 PM	6.00		85	80		
Composite	" 5			313				
No. 22 Cleveland & Cochran	May 29	8 AM	5.70		237	172		
" "	" 29	10 AM	5.70		557	432		
" "	" 29	12 N	5.95		550			
" "	" 29	2 PM	5.70		800			
" "	" 29	4 PM	5.10		360			
" "	" 29	6 PM	5.35		200			
" "	" 29	8 PM	5.10		257	214		
Composite	" 29			657			2,600	
No. 22 Cleveland & Cochran	" 30	8 AM	5.35		107	88		
" "	" 30	10 AM	5.10		337	307		
" "	" 30	12 N	5.35		443	347		
" "	" 30	2 PM	5.70		378	330		
" "	" 30	4 PM	5.10		265	242		
" "	" 30	6 PM	4.55		208	194		
" "	" 30	8 PM	5.35		175	164		
Composite	" 30			407			2,800	

APPENDIX 3 (Continued)

Sewer Outlet	Date 1933	Hour	Flow C.F.S.	Oxygen Demand p.p.m.	Susp. Solids p.p.m.	Volatile Solids	Bacterial Count	pH
No. 22 Cleveland & Cochran	May 31	8 AM	3.60		67			
" "	" 31	10 AM	4.80		388	311		
" "	" 31	12 N	5.10		600	426		
" "	" 31	2 PM	5.10		286	237		
" "	" 31	4 PM	4.55		332	267		
" "	" 31	6 PM	3.60		267			
" "	" 31	8 PM	3.85		230	195		
Composite	" 31			476			2.400	

Appendix 4

APPENDIX 4

SPOKANE, WASHINGTON

REPORT ON SEWAGE DISPOSAL

Inland Empire Paper Company

Inspection June 27, 1933

by

A. D. Butler and Samuel A. Greeley

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We called on C. A. Buckland, the purchasing agent, and M. W. Black, chemist. Both were very agreeable and tried to give us the information we wanted.

The mill has a present capacity of 110 tons of product per day and requires 250 employees. It produces chiefly newspaper, with some wrapping paper and some magazine "print" (used for farm journals). They use some old magazines for making a "very" small amount of a higher grade newspaper "print". This spring the mill has been working 3 to 3½ days a week, but goes at rated capacity while in operation. There are now the following three main departments in the mill:

Ground Wood Mill

Sulphite Mill

Newsprint Mill

The plant has been gradually increased in size and plans are made for further enlargement. The first step will be the replacement of one present machine with a larger one which (as I recall it) will add about 40 tons of output

to the capacity. I presume a doubling of the capacity might be reached. Mr. Buckland said that the mill was not on a 100% closed system, but that in making paper for newspapers, such an objective was not unreasonable.

The water supply of the mill comes from wells except for a fire pump with a rive2 intake. There are four sewers running to the river (See Figure 1).

Sewer A carries the wastes from the wood room. A mixture of white water and fresh water is used here and in the bark drums (which operate 16 hours a day); and some screenings and the like are carried out to the river. They have never made a good measurement of this flow.

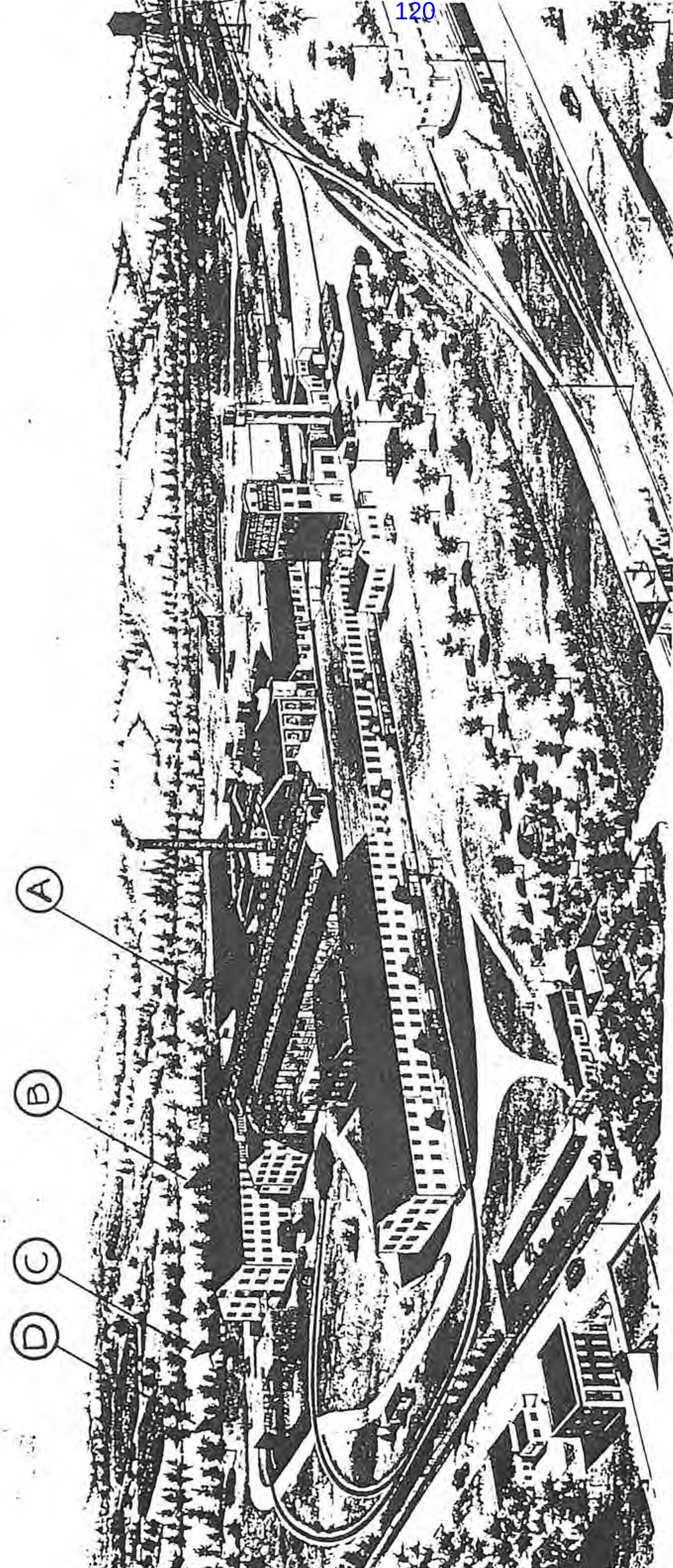
Sewer B gets the sulphite liquor, the piston water from the grinding room and cooling water from the transformer station. Mr. Black estimated the quantity at around 1.5 M.G.D.

Sewer C is said by Mr. Black to carry about one-half white water and one-half clear water to the river. Rough weir measurements indicate about 3.0 M.G.D., ranging from 2.5 to 3.5 M.G.D. This effluent passes through a save-all at the river and the recovered stock is used to make hollow card board shafts in which to roll paper.

Sewer D gets the de-inking wastes from about two tons of old magazines a day. Mr. Black estimates that the sewage carries about one ton of solids per batch and the capacity is two batches per day. The discharge is through a 3 to 4 inch pipe running 6 to 8 hours a day.

The following table is from Mr. Black records for Sewer C:

FIG. 1



PAPER MILL SEWER

June 5, 1933

(Flow in M gals. per 24 hours)

Maximum	Minimum	Average	Lbs. Stock per M gal.	Lbs. Stock loss per day.
M. 5,030	1,727	3,541	3,520	4,155
E. 3,930	3,206	3,531	3,476	4,091
N. 4,160	2,398	3,244	4,004	4,330
	TOTALS:	3,439		12,576

The stock used is mostly white fir known as Lowland Ground Fir (Obies Grandis), with some cottonwood and spruce and a little western hemlock.

Mr. Black estimates the use of water at 45,000 gallons per ton of paper made or about 5.9 M.G.D. when running at capacity. Mr. Black estimates that when making 40 tons of sulphite pulp per day and wasting all the liquor to the river that the population equivalent of the paper mill is 115,000 (same as Spokane). With land disposal of some of the sulphite liquor, he estimates 30,000 to 40,000 population equivalent going to the river.

In Wisconsin (1927 to 1929), a survey was made of the extent of stream pollution from some 55 paper mills in the state. These included ground wood and sulphite pulp mills, board mills, de-inked paper and rag pulp, paper mills and specialties. The following is taken from their tabulation expressed in terms of population equivalent per ton of product:

Item	Population Equivalent per ton of Product (Wisc. data)		
	Average	Maximum	Minimum
Sulphite Pulp	1108	2640	178
Ground Wood Pulp	46.8	92.4	15.6
Board Mills & De-inked Paper	70.8	84.0	51.8
Paper Mills	22.2	54.0	0.2

Calculation of the probable pollution load of the Inland Empire Paper Company based on the observations in Wisconsin would appear as follows:

	Computed Population Equivalent based on Mill Capacity		
	Average	Maximum	Minimum
Sulphite Pulp (40 tons per day)	44,300	106,000	7,100
Paper Mill (110 tons per day)	2,420	5,940	22
De-inking (2 tons per day)	142	168	63
TOTAL	46,862	112,108	7,185

To fix the population equivalent of the paper plant at Millwood would require a more detailed study with analyses of the wastes.

Part of the sulphite liquor is taken by Spokane and is used about the paper mill and by railroads for sprinkling streets and roadbeds to reduce dust, and the amount so used is increasing. This disposal is available from April to October, inclusive, and Spokane could use more if it could be

stored during the winter. White water is used for washing the sulphite pulp and the first washings, down to 3½ degrees Baume at 80 degrees F, are taken for sprinkling streets, while liquor of less than 3½ degrees Baume is wasted to the river. Apparently this sulphite liquor contains more resinous tarry matter than the Wisconsin sulphite waste.

From June 1 to June 27 inclusive in ten operating days they sent out for street sprinkling 452,000 gallons of liquor from 266 tons of sulphite pulp and with better organization might have so disposed of 500,000 gallons. The production of sulphite pulp was 232 tons in April and 307 tons in May. In good times the production is 800 tons a month.